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Chemicals and Human Genes
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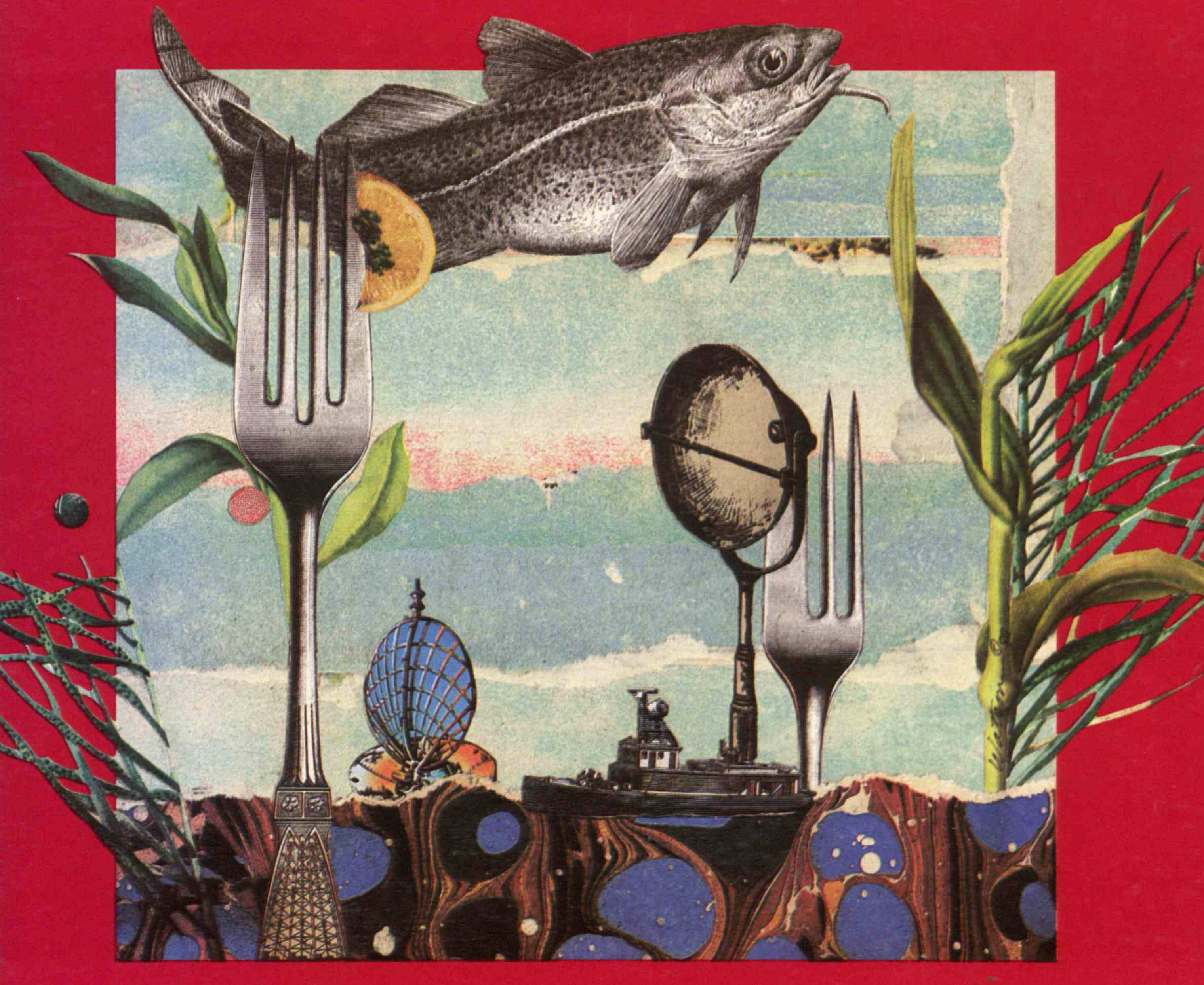
Technology Review

Edited at the Massachusetts Institute of Technology



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Technology Review

FEATURES

World Fisheries in the Twenty-First Century
Page 42

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Gnats Gnawing on Gneiss

Any Irishperson or Scot knows instinctively that Professor Morris Halle's attempt to find logic in the English language is hopeless ("*The Rules of Language,*" *June/July, p. 54*).

Consider his four principles:
1. *m* or *n* do not figure in any (consonant) cluster except *sm* and *sn* (*gnet* is not a possible word);
2. *m, n, l, r, w,* or *y* do not occupy the first position in a cluster (*frith* is a possible word, *lpatch* is not);
3. *b, d,* or *g* do not occupy the last position in a cluster (*bdit* is not a possible word);
4. *p, t, k, f,* or *o* may occupy either the first or last position in a cluster but not both (*sphere* is possible but *pfin* is not).

These principles seem less universal than the Buddha's four noble truths and stimulate these comments:
1. is straining at gnats.
1. and 2. need some mnemonic devices if we are to remember them.
3. is an interesting tidbit but rates no linguistic badge.
4. Do ptarmigans use napkins? They are not apt to, often.

The real possibilities of all this still lie dormant. We all remember the alphabet and its disambiguiting "able, baker, charlie, dog, . . ." I propose this new set as a replacement:

aether (or aisle?)	oedipus
bjorling	ptarmigan
cell	qintar (or qoph?)
dhinn	rote
euthanasia	sea
foehn	tzut
gnus	ubiquity
hsin	vorlage
iamb	wrest
jaiger	xylophone
know	yew
mnemonic	zweiback
nit	

L seems to be the only letter that won't play the game in English; perhaps that's why the Welsh like it so much.
David J. Rose
Cambridge, Mass.

When Morris Halle says that "English words never begin with the clusters *gn* . . .," I believe that a gnarled gnome would gnash his teeth or gnaw on some gneiss while gnats gather on a nearby gnu.
Louis Kruh
Merrick, N.Y.

The author is editor of Cryptologia. *To Messrs. Rose, Kruh, and several other writers, Professor Halle responds:*

Professor Rose's remarks concern conventional English spelling, while my article deals with the actual sounds that those spellings represent. If you sound out the words listed as counter-examples to my rules, you will find that they agree with the rules stated. Thus, *gnat* is pronounced [nat], not [gnat], *ptarmigans* is pronounced with an initial *t* in spite of its spelling, and — though *napkins* contains an internal cluster [pk], I was careful to point out that my rules hold only for initial consonant clusters. I continue to maintain, therefore, that English — as distinct from its spelling system — is perfectly logical in its rules, just like Kasem, Spanish, pig latin, or any other language.

Shaking Down the New Fruit

The lack of a coherent and consensual economic discipline, which Kenneth E. Boulding correctly deplores ("*Economics in Disarray,*" *May, p. 6*), will hardly be remedied until university economics faculties stop tolerating members inclined to fertilize the roots of established mainstream economic theory, having failed to realize that these old roots can no longer bear new fruit.
Monroe Burk
Columbia, Md.

Too Much Handicap for Solar

A correction for "Dusting Off Solar Energy Conversion" (*Trend of Affairs, August/September, p. 80*): the coal consumed by a 10-megawatt power plant is determined by the plant efficiency (normally about 6,000 Btu's per kilowatt-hour in small plants for which extensive pollution-control equipment is not required) and the heating value of coal (about 10,000 Btu's per pound). In this case, coal consumption is about 6,000 pounds per hour instead of the 600 cited.
David I. Katz
Kansas City, Mo.

An AC/DC Vehicle?

"The Case for Fuel-Cell-Powered Vehicles" (*August/September, p. 54*) raises one more question than it answers. Clearly, fuel cells generate direct current; but the

illustration on pages 54-55 shows propulsion by an alternating-current motor. Has there been some major technological breakthrough to account for the operation of an AC prime mover from a DC source of power?
Edwin Olmstead
Mount Holly Springs, Pa.

No breakthrough; just an overly secretive black box ("G" – motor controls) in the illustration. That box contains both a "chopper," to vary the DC input voltage from the fuel cell, and an inverter, to change DC to AC, and we apologize for not being specific. – Ed.

Distinctions in Igloo Building

My observations as a witness and sometime participant in the building of snow-domed igloos (*"Rediscovering Energy-Conscious Architecture" by Selma Newburgh, August/September, p. 68*) were that these buildings are built by cutting carefully selected snow into blocks that are laid in a spiral to form a dome. The joints are caulked with powdered snow, and snow is sprinkled over the exterior.

Even though the domed igloo is made of snow (the "R" factor of snow is quite different from that of ice), there is a period in the early fall before the snow comes when the ice is thin. Sometimes the Innuit cut sheets and slabs of ice and erect rectangular structures with vertical walls and roofs of skin as interim houses. Perhaps the author has mixed the techniques.
John J. Scheuren, Jr.
Hingham, Mass.

Mr. Scheuren is associated with J.J. Scheuren and Sons, engineering and planning consultants.

Insulation versus Heat Storage

Selma Newburgh says that earth "is an excellent insulator with a high capacity to retain heat." It is disappointing to find such an obvious error in an otherwise enjoyable and entertaining article. Earth does have a high capacity for heat retention, which makes it excellent thermal mass, but it has almost no value as insulation. Insulating materials stop heat from penetrating, or at least drastically slow its action. Mass absorbs heat. The confusion of the two can lead to major design errors.
Jim Wilson
Vermillion, S.D.

Mr. Wilson is a solar design consultant.
Ms. Newburgh responds:
Mr. Wilson's point is well taken. However, we should keep in mind that the effects of "two inches of insulation" and "three feet of earth" are similar. They both reduce the rate at which heat flows from one side of the space to the other. While each material achieves this effect on the basis of different physical properties, the result is the same: controlled temperature levels within an enclosed space.
Continued on page 88

Working Smarter

A new buzz-word is coming into vogue among people concerned about America's economic decline. The word is *reindustrialization* — as in "the reindustrialization of America." It bespeaks the need to revitalize the economy and reverse America's slide into an economic second-rater.

The marks of malaise are all around — unemployment lines, declining living standards, entire industries in trouble, whopping foreign trade deficits. Small wonder there's so much attention being focused on ways to reindustrialize America and get our economy back on a growth track. "Even the trendy set in economic policy has sensed that something is wrong in the American economy," says one economist.

One of the main things wrong is the stunting of productivity. Productivity, or output per employee, is a key measure of economic health. When productivity grows, so does the economy in real terms, raising people's living standards. When it declines, real economic growth slows and stagnates. Increased productivity also yields resources to meet public needs, such as reducing poverty and improving environmental quality.

America traditionally has led the world in overall productivity. It still does. But other countries are catching up. If current trends continue, Japan and West Germany can be expected to surpass us during this decade. Among the non-communist industrialized nations, the U.S. lags at the bottom in productivity growth. The grim results are higher prices, unemployment, lower real pay, and a blunting of U.S. competitiveness in world markets.

American productivity actually declined in 1979 for only the second time in the last three decades. It grew at about 3% a year during the 1950s and 1960s, then slumped to less than half that rate during the '70s. Had we maintained the 3% rate during the last decade, real U.S. output would now be about $400 billion higher. Personal income would be up about $4,000 per household.

Raising productivity doesn't mean working harder. It means working *smarter*. And this demands large doses of the twin I's — investment and innovation.

More money has to be channeled into capital investment for the modern plants and machines that enable people to work more efficiently and productively. Research and development must be stepped up in the quest for new technologies and innovative ways of doing things.

Whatever has happened to Yankee ingenuity, anyway? The number of U.S. patents issued to Americans has fallen 25% since 1971 while the number issued to foreigners has risen 14%. About 40% of the patents now issued by the U.S. go to people from other countries. America's most formidable foreign competitors, Japan and West Germany, outperform us both in capital investment and research and development measured as a percentage of total national output.

The reindustrialization of America must start with recognition that invigorating our productivity is a top imperative.

Policies and programs are needed to expand saving and investment, stimulate technological advances, enhance the climate for risk-taking and innovation, encourage adequate corporate profits, and ease the tax and regulatory burdens that undercut business' ability to create, compete, and produce.

Nothing less than a rebuilding of the nation's productive might is required if America is to regain its economic health.

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On the Virtues of Muddling Through

Kenneth E. Boulding is a program director at the Institute of Behavioral Science and distinguished professor emeritus of economics at the University of Colorado at Boulder.

WATCHING the great television debate between President Carter and President-to-Be Reagan cheered me considerably in the midst of an election not noted for cheer. It was a magnificent example of the most fundamental principle of American politics, which might be described as the slide toward the middle. In a two-party system, and even in the 2.1111-party system that we now seem to have, a candidate, to be successful, must get close to 50 percent of the vote. This means that moving toward the middle is always a better strategy than moving toward either extreme. Taking an extreme position means losing in the middle with little gain among the people who would likely vote for you anyway.

This does not necessarily mean, of course, that the middle is always the best place to be. There are times when we might do better at one or the other extreme, but these cases are rare. The middle almost has to be a muddle, and in a highly uncertain world, there is considerable probability that muddle is the right strategy. To muddle through is to keep many options open and commit to none too much — as things change we can change with them. An extreme may be all right under conditions of certainty when we want to zero in on an optimal solution. Muddle, inefficiency, and redundancy, therefore, are great sources of evolutionary potential and survival — the clarity and efficiency of the extremes are an almost sure passport to extinction. This principle was so evident in the debate that I decided that it didn't matter very much whom I voted for.

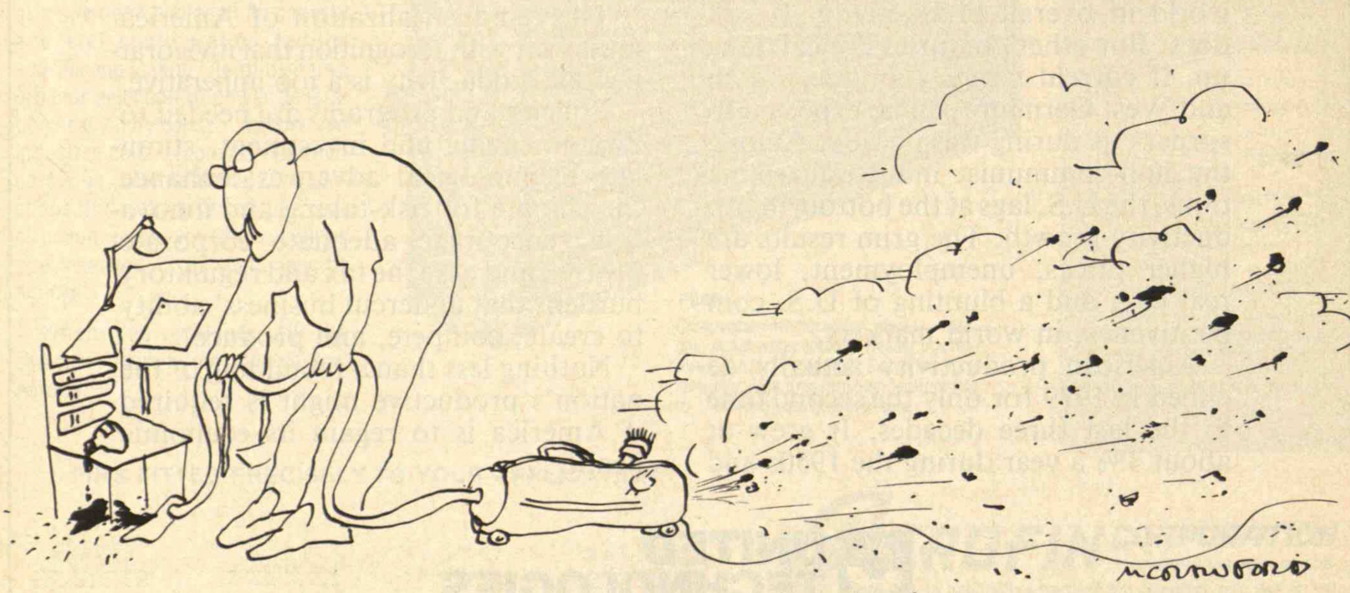
Secular Sacraments

I did vote, of course, like a good citizen, but I did so essentially as an exercise of the civic religion. In spite of its usually depressing architecture, a voting place is strikingly reminiscent of the atmosphere at 11 A.M. on a Sunday morning. Virtue shines from every face, and there is a vergerlike quality about the worthy citizens who check your name and address and give you a ballot. There is even a slightly sacramental quality about the voting booth. The ballot is a wafer placed on the trembling tongue, and even if a little of the magic is lost when the ballot is punched, one drops it into the box almost with an "Amen."

The great debate ended with another happy ritual — the candidates shook hands, an old symbol certifying that they carried no weapons. In a successful democracy, the slide toward the middle also ensures a ritual dialectic very much like sport — it doesn't really matter who wins, but we have to pretend it does. Politics is a game played according to certain rules, the major one being that the outcome will be accepted by both parties. There is an evolutionary principle that fighting, particularly within species, must be ritualized or it leads to extinction. The rituals of fighting are presumably implanted genetically in most animals; in humans, they are largely learned through culture, often a painful and costly process. Those cultures who do not learn to fight are in for trouble and possible extinction.

Cooperation and Economic Growth

The principle that those who ritualize conflict are much more likely to succeed than those who do not is one of remarkable scope. Family rituals often involve a good deal of violence and pain, but the marriage survives, like that of Andy and Flo Capp and the Lockhorns of the comic strips. We see this principle operating in certain towns and communities. In the anthracite coal fields of Pennsylvania, decades of labor strife created a climate in which adjustment to a decline in the industry was extremely painful and difficult. However, the town of Hazleton built an industrial park, undermining the power of



Michael Crawford

the old corporations without really fighting them, and prospered.

On a somewhat larger scale, Cleveland and Pittsburgh are good examples of two rather similar cities with different capacities for adjusting to adversity. Pittsburgh cleaned itself up and survived the decline of its old industries by attracting new ones. Cleveland remained highly dialectical — its political and corporate structures continually in conflict, its ethnic minorities pulling in opposing directions, its upper class fleeing to the suburbs — and it now shudders on the edge of bankruptcy.

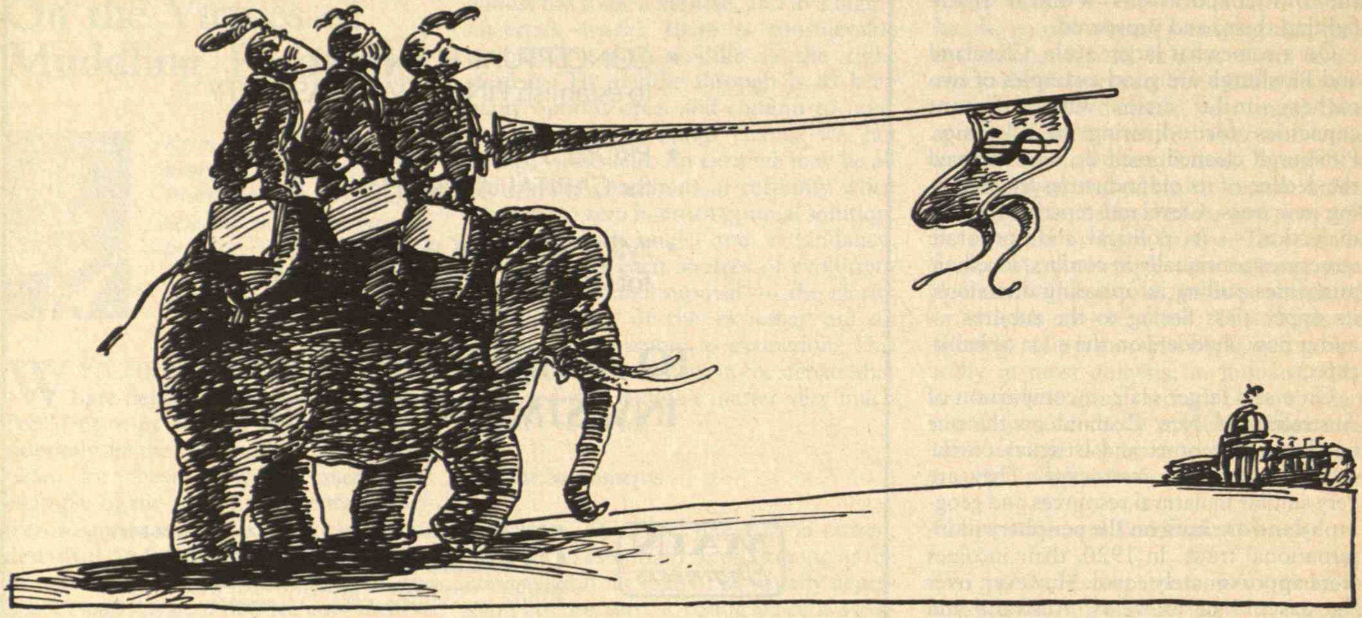
On a still larger scale, a comparison of Australia and New Zealand on the one hand and Argentina and Uruguay on the other is extremely instructive. They are very similar in natural resources and geography and are both on the periphery of international trade. In 1920, their incomes were approximately equal. However, over the past 50 or 60 years, Australia and New Zealand have continued to get richer, have sustained democratic institutions, and are without internal violence — they are almost unnoticed by Amnesty International. Argentina and Uruguay, on the other hand, have stagnated economically and have gone over a cliff politically into tyranny, torture, and a gross disregard of individual human rights.

Australia and New Zealand are profoundly nondialectical societies: they have never had a revolution, they sustain symbols such as the monarchy, and class conflict is a political ritual. In Australia, the aborigines have had a very hard time, but in New Zealand, the Maoris and other Polynesians are being integrated into the society with some success.

By contrast, Argentina and Uruguay have been highly dialectical, with intransigence a political virtue and atrocious internal violence from both left and right. Australia and New Zealand now have almost three times the per capita incomes of Argentina and Uruguay. Japan, of course, is a supreme example of a society in which conflict is highly ritualized, in which military defeat, by clearing out the major dialectical elements in the society, ushered in an era of unprecedented economic growth. The message rings loud and clear: "Cool it, take it easy. Play at conflict, don't work at it, and you'll end up both richer and, with a bit of luck, happier." □

Reagan and Technology: A Camelot for Free Enterprise?

by Edwin Diamond and Norman Sandler



Jon McIntosh

ON a sunny morning in Washington last November, a group of American Nobel Prize winners filed into the Oval Office of the White House. A tired-looking Jimmy Carter, winding down his presidency, greeted them for a "photo opportunity" — a handshake, a group portrait that each laureate could hang on his office wall, and a short colloquy with the president. Carter, who had often boasted of his engineering training, praised the scientists for furthering a "better understanding of the universe God gave us."

"Long after the work of statesmen has been forgotten," he continued, "the work of these men will be remembered. In the last three years, we have seen a reversal of the trend of less commitment to science, and I intend to see that commitment continued."

In the silence that followed, no one was sure how an elected president turned out of office by the voters — the first to be thus treated since another engineer-president, Herbert Hoover, in 1932 — might affect national policy toward science and technology. In fact, interest had already changed, in one of those shifts establishments perform so adeptly, to Ronald Reagan and his plans for science and technology during the next four years. And so, even as the laureates paid court to the outgoing president, they were being asked about the new occupant of the Oval Office.

"With Carter there was the clear feeling that he appreciated the importance of science," Hamilton Smith, a 1978 prize winner in chemistry, told the *Washington Post*. "Reagan is an industry and technology man, and that's good." "It depends on his advisors," said Julius Axelrod, a winner in 1970 for his work in neurobiology.

All the President's Advisors

One reason Ronald Reagan's advisors will be so important is the president-elect's rather casual personal attitude toward science and technology. Jimmy Carter clearly enjoyed technical discussions and problem solving — indeed, one complaint about his presidency was that he tried to reduce complex policy problems to engineering diagrams. But his engineer's approach as well as the Democrats' traditional goodwill toward science and technology resulted in increased federal research funds. Ronald Reagan, on the other hand, is known to correspond with clairvoyants and follow the horoscope columns in newspapers. During the campaign, he advocated teaching Biblical theories of creation in public schools and dismissed Darwinian evolution as "just another theory." Perhaps more important, Reagan has pledged to cut nondefense federal spending. Indeed, Reagan advisor Milton Friedman, saint of the conservative movement, has urged ending *all* federal support for basic research at universities.

However, Reagan has been getting less extreme advice from his other science advisors, who will no doubt shape much of his policy. The Reagan scientific wise men — there are no women — include Simon Ramo, of TRW; Arthur Beuche, General Electric; Harold Agnew, General Atomic (and former head of the Los Alamos National Laboratory); William Baker, Bell Labs (science advisor during the Nixon and Ford years); Edward David, Exxon (and former White House science advisor); Franklin Murphy, the Times Mirror Co.; William Nierenberg, Scripps Oceanographic Institute; Lewis Sarett, Merck; Bernard Schriever, retired USAF major-general; Frederick Seitz, former president of Rockefeller University; H. Guyford Stever, former head of the National Science Foundation; Wilson Talley, research director of the Environmental Protection Agency under Ford; Edward Teller, the physicist; Theodore Walkowicz, National Aviation and Technology Corp.; and Albert Wheelon, Hughes Aircraft.

Some strong clues as to the shape of Reagan's policy already exist. Wall Street, that racy barometer of smart-money thinking, sent defense and high-technology stocks surging immediately after the election. The market hunch was that a Reagan presidency would release regulatory and other shackles on industry, giving way to unfettered energy production and a more favorable "business climate." Specifically, a boon for the oil and defense industries was expected.

Reagan and his advisors, currently preoccupied with budget balancing, tax cutting, and weapons production, have paid little attention to determining where science and technology will fit in. Technology didn't have many friends in the core transition team — none of Reagan's inner circle of advisors has a technical background. Several are lawyers, a few are economists, and others — the "California crowd" — come from retailing, car sales, and entrepreneurial backgrounds.

Reagan has not gone out of his way to reassure the scientific and academic communities that he intends to be their friend. Nevertheless, it is tempting to hope for the best. "My guess is that the support of science and technology is bipartisan," Carter's science advisor Frank Press told us. "The kinds of people Reagan has advising him and the few statements we've seen so far tend to support the view that the health of American science and technology is and will continue to be an important item on the national agenda."

The Shape of Things to Come?

But the realities of Washington are that science is one voice among hundreds vying for scarce administration dollars and attention. There is also the antigovernment, probusiness theme of the early Reagan campaign speeches.

For example, there is talk — not yet substantiated — of dismantling the Council on Environmental Quality as an unnecessary advocate for the environmental movement. But no evidence suggests Reagan would make more drastic changes in policy apparatus such as abolishing the White House Office of Science Policy. Here's what our own crystal ball shows:

Overall policy. The primary emphasis in science and technology under the Reagan administration is likely to involve the same priority established by Carter — channeling resources toward solving the nation's most immediate and pressing problems. Productivity and innovation are the keys to placing the economy back on track in the minds of many Reagan people. The importance of achieving a better competitive position for the United States in the production of high-technology goods suggests that Reagan will concentrate on applied research. Some fear that this will be done at the expense of basic research, a critical source of funding for universities.

Reagan's faith in the free-enterprise system is a major factor in these uncertain equations. Reagan is expected to use tax write-offs and other incentives to spur private-sector involvement that will augment, and possibly replace, direct government sponsorship. This would also tend to favor applied research over wide-ranging basic research, which may or may not produce practical applications.

Both Ford and Carter — but primarily Carter — worked toward forging a closer partnership between universities and industry, a pursuit that will continue under the Reagan administration. According to one Reagan advisor, "With budget pressures and the need to strengthen industry and our research base, I think you'll see even more initiative coming from the private sector."

Basic research. The emphasis on applied research raises questions about the future of basic research, especially that centered at the universities. Reagan advisors concede that a tight federal budget will force trade-offs pitting potential long-term benefits against more immediate needs, and basic research very may well feel the pinch.

"The pendulum is always swinging one way or the other, and right now people are kind of desperate," said former National Science Foundation head H. Guyford Stever, a Reagan advisor. "We have to relate science and technology to our needs. There are lots of areas that want money and they aren't all going to get what they want. . . . There will have to be priorities. Hopefully, there will be no vital organs hit in science and technology."

Solar Advocates Worried

Energy. Reagan's emphasis on "turning loose" industry to boost domestic energy production complements the goal of reducing the size of the "energy bureaucracy." Those who have seriously examined Reagan's casual proposal to abolish the Department of Energy, however, predict that most programs would remain intact even if the new administration successfully pursues this goal. In Washington, skilled officials know how to preserve programs by tucking them away in different federal agencies. At the same time, there is nervousness about possible cutbacks in energy research and development as emphasis shifts to conventional sources such as nuclear energy and fossil fuels.

However, Reagan policies could mean more money for high-cost technologies such as the nuclear breeder reactor, coal liquification, and oil shale. The solar industry is worried, although Reagan advisors insist all possible sources of energy for the future will be encouraged. No major change has been mentioned for the fusion program, which requires massive federal funding, nor for esoteric proposals such as harnessing the ocean tides.

Defense. The prospective shelving of SALT II and a commitment to increased military spending suggest Reagan's election will be a boon to defense research. But much of the proposed increase in the defense budget could end up in programs other than research and development — for example, production and deployment of existing technologies; building up the supply of ammunition, nuclear weapons, and other inventories; and higher military pay. Reagan's campaign rhetoric tended to focus not on technological innovation but on pushing ahead with projects already on paper, such as the neutron bomb, the B-1 bomber, the nuclear carrier, and the MX missile.

But the prospective abandonment of SALT II leaves the field wide open for improvements in the accuracy and reliability of existing systems and the development of new systems — lasers, antisubmarine warfare, air defense — suggesting heavy investment in military research. The Reagan administration will also discover that all the bold talk of launching a fleet of new nuclear carriers in response to developments in the Persian Gulf runs aground on the shoals of the real world: it takes no less than 15 years to design, authorize, build, and outfit a new carrier.

The space program. Reagan has said nothing about the space program, one area about which even his advisors refuse to speculate. Their comments tend to suggest that because Reagan is determined to meet his budget-cutting goals, the space program will continue its slide. There has been no talk of accelerating the Space Shuttle program or advancing the as-

Continued on page 88

Edwin Diamond is a veteran journalist and senior lecturer in political science at M.I.T. He was recently appointed associate editor of the afternoon edition of the New York Daily News. *Norman Sandler, who received his S.B. degree from M.I.T. in 1975, is a UPI correspondent in Washington.*

How to Develop Industrial Slums

by Richard Muther

ABRAHAM Lincoln observed that God must have loved the poor, or he wouldn't have made so many of them. The same may well be said of industrial slums. In both cases, inequitable social conditions aid the "creator" substantially, but while it takes many years and individuals to produce impoverished populations, a bona fide industrial slum can be readily implemented, with a minimum of resources, by any willing entrepreneur.

Of course, industrial plants seldom achieve their full potential for ugly, polluting, unsafe, and degrading sluminess, but if you want to be immortalized as unusually adept at working toward that end, here are 12 ways to begin:

1. *Select a plant location in a community that has no building codes or that fails to enforce them.* Such a community is almost certain not to stand in your way. Where construction permits are granted randomly and building inspections are only a formality for graft or payoff, your advance toward shoddiness is well underway.

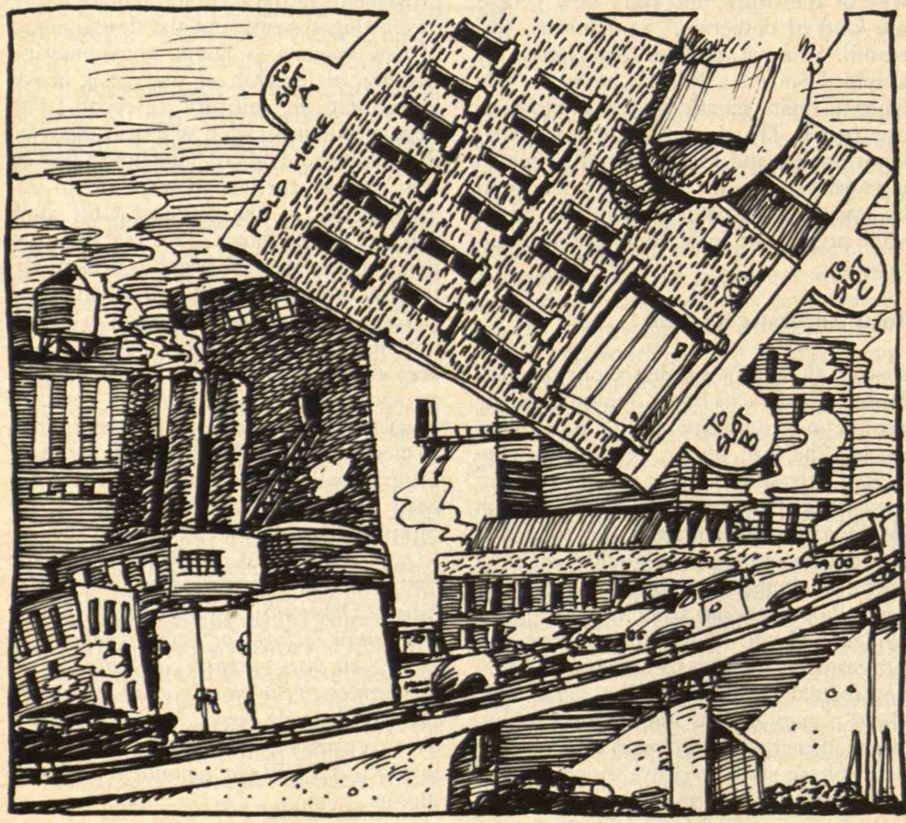
2. *Choose a site already surrounded by slovenly neighbors.* There will be no complaint about your disturbing the scene, and you can count on shabby surroundings to be contagious.

3. *Procure or provide land that is awkward in shape, irregular in slope, inconsistent in subsoil, and divided by streams, public roads, railways, power-line easements, and the like.* If your land is so subdivided, you have the opportunity to provide your plant with congested conditions. And the more divisions provided by natural causes, the easier it will be to let nature work for you.

Divisions caused by public rights-of-way lacing through your land are conducive to fragmented buildings. And divisions involving railroad embankments and stream valleys, awkward materials handling, and utilities greatly facilitate rotten service. Land contours are also important — if they are overly steep, they create walls, steps, and ramps sure to inhibit efficiency and flexibility.

4. *Choose an undersized site or building.* Then crowd your buildings and equipment into a cozy, closely knit arrangement. This leads to savings in land costs and rental charges, but its major benefit is that it leads almost automatically to cramped, congested, and constipated operation.

In the manner of sardines in a can, where the oil costs more than the fish, some managers and facilities planners believe that the close fit of buildings and equipment is more important than a smooth operation. You should select such leaders.



Jon McIntosh

5. *Do little or no planning.* Especially avoid long-range planning. Then you won't have any worries about preparing a master site plan or selling it to a board of directors, and you won't have to waste time on complex integrations of layout, handling, controls, utilities, and buildings.

Keep yourself flexible. By remaining indecisive and avoiding direction, you are free to proceed at your own pace toward developing your best possible industrial slum.

6. *Never start analysis and design of facilities until they are needed.* This creates an exhilarating helter-skelter of crash programs and crunched work schedules. To plan ahead is patently wasteful.

7. *Don't spend any time or money on an organized facilities-engineering effort.* Every facility's problem is unique — each has its own special requirements — so why create makework for so-called planners? Why try to organize something that is essentially esoteric?

Instead, set up a committee — with an irresponsible chairperson and members with little experience and time. Then, without a clear objective, plan of attack, and schedule, you will assure noncoordination and a squandering of intellectual effort. When the time comes, you can surely find a licensed engineer to redraw and put a stamp of approval on the sketches you scratch on the back of an envelope.

8. *Never make serious use of an architectural-engineering firm or qualified specialist.* Or, if you must, be sure to select one that doesn't understand the particular problems of industry: one who never heard of words such as "function," "profit," "flexibility," "expansion," "service," "versatility," or "resale value." One shouldn't waste time with such idle abstractions.

Select an impractical architect with a reputation for wildly illogical structures and spatial ambiguity, one who is fascinated with unreasonable and incoherent building systems and whose structures defy orderliness, harmony, consistency, and functionality.

9. *Always select the cheapest investment.* This is another way of saying: listen

only to your accountant. Make it a rule to take the lowest cost on materials, land, and equipment. Never consider the resale value of your facility or look for intangible, "secondary" long-range benefits. Don't borrow money to finance anything. Above all, avoid purchasing things because they are nice, logical, pleasant, pleasing, convenient, reliable, safe, proven, or in the interests of the community.

10. *Employ an unreliable building contractor.* Fly-by-night contractors or equipment suppliers go a long way toward generating quick deterioration. Rehabilitation programs lend themselves especially well to covering over and covering up.

11. *Drastically reduce your budget for maintenance.* Better still, *eliminate* maintenance and improvements on plant and equipment, letting the facilities run down and wear out naturally. This is one of the easiest ways to inject debilitation into your plant.

12. *Shun all efforts at landscaping and beautification.* Crowd property lines with structures. This produces congestion and forces you to hang supporting equipment, such as dust collectors and cooling towers, clumsily on the sides of the building. Parked cars can be completely exposed on a barren parcel of dusty gravel or mud. Scrap and trash can be collected in front yards. Discarded trimmings and paint can accumulate close to the highway. And a graveyard of broken storage containers, rusted racks, and obsolete piping and duct work can surround your buildings with distinct ugliness.

Despite my best advice, you simply may not *want* to develop industrial slums. You may be one of "those people": a manager who is concerned about the company's future facilities or a planner who is prepared to protect and preserve its largest investment. In that case, see the accompanying box. □

Richard Muther is president of Richard Muther & Associates, consultants in industrial engineering and management. He has authored several books on facilities planning and recently received the Engineering Citation from the Society of Mechanical Engineers.

Twelve Ways to Avoid Industrial Slums

1. Select a location in a community with good building codes and a record of enforcing them.
2. Choose a specific site surrounded by well-kept plants — especially if there are guarantees of their upkeep.
3. Procure a site physically conducive to good facilities and their planning.
4. Obtain a site or building with adequate land or space so that expansion, rearrangement, and changes can be accommodated without extensive disruption or premature abandonment.
5. Plan your facilities for the long range and encourage management to think about the long-term retention of value in plant and equipment.
6. Start planning, analysis, and design before facilities are needed.
7. Hire an effective staff with appropriate skills and establish suitable procedures for facilities engineering.
8. Use a qualified architectural-engineering firm and other experienced professionals to keep your facilities pleasant and harmonious, economically up-to-date, and compliant with laws and regulations.
9. Evaluate investments in facilities for their true economic return and their intangible and/or long-range benefits.
10. Engage a builder and contractor with reliable workers, riggers, and suppliers.
11. Avoid sabotaging your maintenance budget. Even in the face of financial stress, don't let your facilities get into irretrievable states of disrepair.
12. Give attention to appearance — landscaping and a coat of paint can often do wonders.

A Valentine for NASA

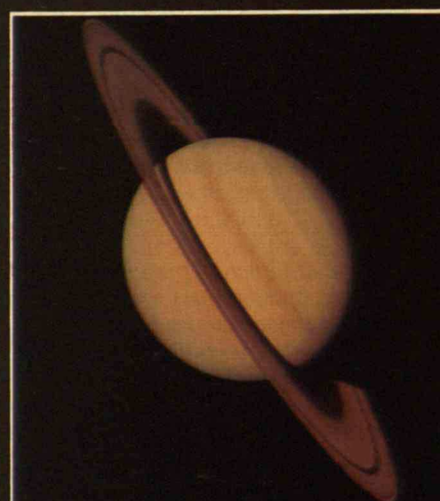
Robert C. Cowen, science editor of the Christian Science Monitor, *is former president of the National Association of Science Writers and a regular contributor to the* Review. *He holds S.B. and S.M. degrees from M.I.T.*

As *Voyager 1* swung triumphantly past Saturn and headed for outer space last November, a newspaper cartoon captured the mixed feelings of American space scientists. It shows two people in the mission control center, one of whom looks wistfully out at the stars. The caption reads: "From Rhea it goes to Hyperion, on to Iapetus, then out beyond our budget system."

This indeed is the perspective of scientists and managers on the highly successful Voyager project and the planetary program of which it is a part. Elated by its achievements and challenged by the knowledge it has produced, they look wistfully to the larger community in the hope that people care enough about this national enterprise to keep it going.

Pinched by tight funding and grounded by delays in the Space Shuttle, now the only launch vehicle available for interplanetary missions, these scientists and managers face a five-year lull in planetary exploration. *Voyager 2* is scheduled to make a follow-up survey of the Saturn system next August, but it won't reach Uranus, the next planetary target, until January 1986. There is no other mission — authorized or requested — that could produce anything within that time. This has raised fears that the public and Congress might lose interest and let planetary exploration fade away, and this concern has produced some interesting reactions. Scientists and administrators at the NASA Jet Propulsion Laboratory (JPL) for the Saturn flyby seemed encouraged by Ronald Reagan's election to the presidency regardless of their personal political convictions. They looked hopefully, even expectantly, to his administration to inject new life into their program. They felt that he, like themselves, would see it as an element of national strength that should not be allowed to wither.

More significantly, perhaps, they are



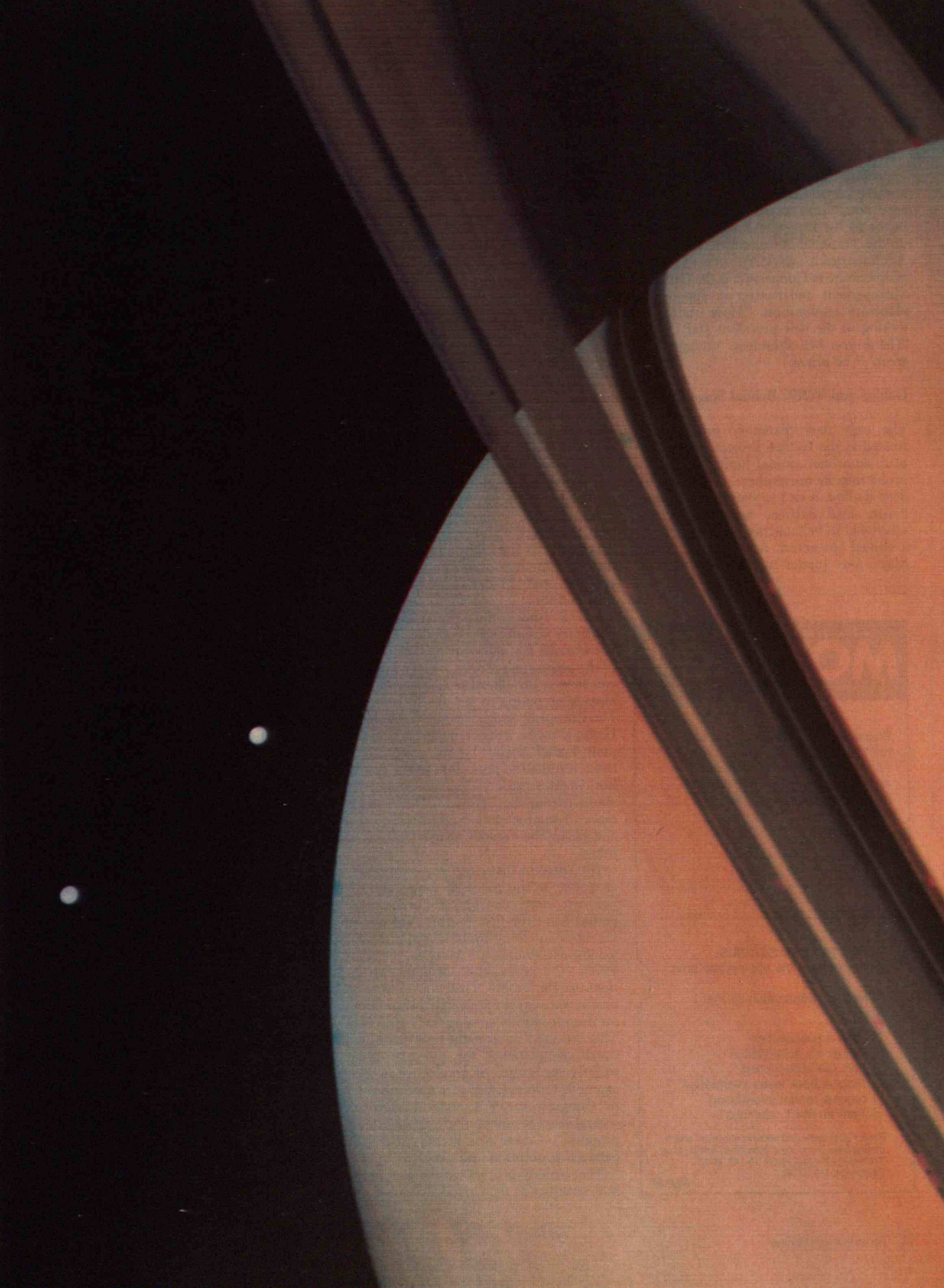
A Saturn Spectacular as the U.S. Planetary Program Winds Down

Designers of the twenty-first century will be hard put to create such a visual extravaganza as Saturn sent to earth from *Voyager 1* last fall. It was a scenario for discovery almost without parallel for American science. In a period of less than two weeks, an object of intense curiosity and speculation for decades — even centuries — was illuminated by cameras that worked almost flawlessly to resolve features as small as 40 miles in diameter. No wonder that as the prodigal week ended (with only one more spacecraft now approaching Saturn and then Uranus five years hence, and no other mission even fully planned), the excitement generated among space scientists by pictures such as these had a thin overburden of wistful yearning.

Voyager 1's pictures revealed Saturn's rings to be vastly more complicated than earthbound astronomers had imagined — "a bottomless pit," said Bradford Smith of the imaging team, with rings laid next to rings like grooves in a phonograph record. How to explain these countless circumferential collections of ice and dust? And, in particular, how to explain the radial "streaks" or spokes that seem to link the rings in parallel with Saturn's diameter? The rings themselves continue to be attributed chiefly to gravitational resonances, but Dr. Smith told *Science News* that "there's no way resonances can explain all of this . . ." And the spokes, he said, are "quite clearly the most baffling surprise . . ."

The clouds representing the planet's surface (*top, left*) also held a surprise: winds on Saturn are far stronger than on Jupiter. But Saturn is smaller and, presumably, cooler than Jupiter; whence this prodigious wind energy?

As *Voyager 1* left Saturn, the count of that planet's moons had risen to 15 and careful studies of the photographs may reveal more. Dione (*top, right*), just over 1,000 kilometers in diameter and made mostly of ice, is the least exotic in appearance, most like Earth's moon. But unlike the moon, Dione may be alive: Laurence Soderblum of the U.S. Geological Survey hypothesizes that Dione could contain enough radioactive material to provide significant heat, with smoothing of craters, crustal cracking, and perhaps even outgassing from within. — *J.M.*



appealing directly to the public as their natural constituency for support. "We need you," said Angelo Guastaferro, director of the Planetary Program Division of the National Aeronautics and Space Administration (NASA), in suggesting people write to Congress and the Office of Management and Budget in support of planetary exploration. "How about . . . writing to the new president and saying, 'Thank you Mr. President. Voyager was great,' " he urged.

Galileo and VOIR: Behind Stage Doors

The only new planetary project now funded is the Galileo Project, which will place an orbiter around Jupiter and send a probe into its atmosphere. Its timing, indeed its fate, is tied to that of the shuttle. Probe and orbiter were originally scheduled to be launched early in 1982 as a unified spacecraft. At that time, Earth, Mars, and Jupiter will line up so that, when the spacecraft would have reached Mars, that planet's gravity would have boosted it on to Jupiter. Now the lanch date has slipped to 1984. Mars will still be useful. But this compromise date is contingent on operational certification of the shuttle, scheduled for its first test flight in March 1981.

President Carter did give space scientists some encouragement when he congratulated them on the Saturn flyby, saying that the Venus orbiting imaging radar (VOIR), a long-planned and much-desired mission to map the surface of Venus in detail, is in his 1982 budget. Scientists' joy, however, was tempered by the realization that the project must also win approval from the incoming Reagan administration and that some tough trade-offs have been involved. NASA has had the VOIR postponed before as mounting costs of the shuttle gobbled up limited resources. Now it is finally in the budget at the cost of a once-in-a-lifetime opportunity to send a probe to study Halley's comet, due to return in 1986.

It's a compromise most American planetary scientists do not like. They are not worried that humanity will be cheated of this opportunity to see what the famous comet is really like. Other countries are already preparing to get the information. The European Space Agency (ESA) has a Halley's probe project underway, and a joint French-Soviet Venus spacecraft is being rerouted to pass close to the comet. But American space scientists are worried about letting the hard-won U.S. competence in solar-system exploration go soft and seeing the nation's leadership pass to others.

JPL Director Bruce Murray is especially articulate on this point. He notes that the five-year hiatus can be compared to the period from the first Ranger missions to the moon in 1963 through the spectacular Viking exploration of Mars in the mid-1970s — a period that included expeditions to the moon. There never was as much as a year without new information on distant worlds coming back to Earth. This reflected an equally long period of consistent planning for projects in an orderly program of exploration. For example, although Voyager was approved by Congress in 1972, work had begun several years before on the detailed project proposal — there was literally a decade between conception and payoff.

That orderly process was broken in the mid-seventies as the United States became preoccupied with internal problems, Dr. Murray explains. "In a sense," he says, "we who have created our society and our future based upon technology and energy lost our confidence. We dropped the ball. . . . In that process, we did not start a number of reinvestments. For example, we did nothing to follow up the Viking mission to Mars."

"The real issue now," he adds, "is accepting the fact that there is going to be this interruption and hiatus. Do we want to continue to excel? Do we want to do things, do we want our children to do things, in which we and they can take pride just as the American people now take pride in the [Voyager] decision made ten years ago? Are we willing to make those decisions? Are we willing to put money behind them? . . . I think that is the current question. And I think it's part, perhaps, of a number of questions on the national scene: Where are we headed as a people? And if we intend to excel, if we intend to do things we can be proud of, certainly this exploration can be one of them."

Dr. Murray speaks for many of his colleagues. They do indeed see their planetary program in the larger context of the overall national purpose. This is not to say that the program is moribund. NASA currently is spending just under $600 million a year on space science, $200 million for solar-system exploration and ongoing research in comparative planetology and data analysis. It supports the deep-space monitoring network and the mission-design team at JPL and maintains data reception for 12 interplanetary vehicles, some of which have exceeded their normal lifetimes. Even passing up the Halley's comet opportunity is not a foreclosed question. NASA is exploring the possibility of a joint U.S.-ESA project and continues to study the option of a U.S. program.

But this is a holding operation that cannot continue; without new growth, the planetary program will eventually falter. Hence the plea for public support to encourage the incoming administration to do more in space.

There are grounds for hope. By now, Mr. Reagan has assumed office and may well have outlined his space policy. Meanwhile, as a space buff, I cheer on the Guastaferros and the Murrays. "Keep the cards and letters coming," they say. OK NASA, here's my valentine. □

Why Study Saturn? Why Not?

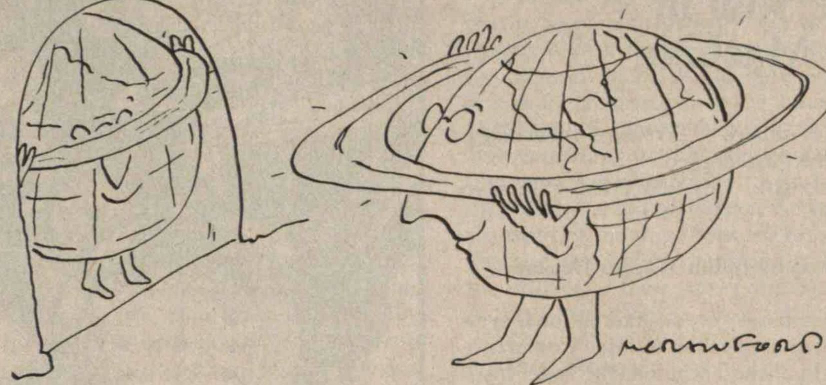
by Daniel Menaker

Saturn is now much closer to us than it was before the recent flyby. Looking at Saturn now is like looking at a street light eight thousand blocks away, whereas before the flyby looking at Saturn was like looking at a street light sixteen thousand blocks away.

Saturn is as large as seven hundred and fifty earths and some change. It has thirty-three moons — Lapidus, Titian, Methedrine, Janis, Mouli, Insalata, Urea, Bob, Studio, Eor, Choline, Arturo, Tetley, Acadia, Maupintout, Crayon, Tertullian, Abacus, Gardol, Amster, Mingo, Quart, Trinitron, Bilalian, Pylon. Let's see . . . Cretin, Lachrymose, Fido, Runnymede. Vegas, Tertullian II, Cleon. That's it. Let's see . . . thirty, thirty-one, thirty-two. Oh, yes — Leonia. Thirty-three. The moons range in size from Amster, which is about as big as a bladderball, to Tertullian II, the size of our own moon — which, incidentally, still takes a back seat in comeliness to no other satellite in the system.

There has been a nearly Jacobin determination by scientists to give each of Saturn's moons equal attention, but it can't be helped if some of them seem to clamor for special consideration. Runnymede, for instance, is an immense ball of very thick rope, and during the fly-by a picture sent back of this baby showed thirty or forty loose ends, some of them more than a thousand miles long, trailing behind it, as if it were a baseball that had gone through a doubleheader without its cover. Acadia is utterly transparent, and may not be there at all. Crayon has a polar orbit. (All the others have equatorial orbits, and it looks as if Crayon will smash into Lapidus, Studio, or Janis one of these days. So far, it has managed to sift through safely.) Cleon stops dead in its tracks from time to time. Tetley has three deep creases on its dark side, which makes it look astonishingly like a forehead furrowed in thought. And Arturo — a great favorite with many — is emerald in hue and pulses out to twice its normal size at apogee.

Back to Saturn proper (though, in view of the findings about the planet itself, any weakness for the moons is understandable). Saturn's composition is the usual — broken chunks of cinder block, pottery shards, the rotting trunks of felled oaks, brown creek beds, gigantic balls of dried caulking, and Spackle and grout. Old, decomposing cedar shingles. The only thing not predicted was the thousands of round red-brown spots, which turned out to be the heads of huge rusty nails, or spikes, unevenly spaced all over the planet and driven in by no one knows who. The implication of agency is implied with confidence, because each of the nails is surrounded by random, semicircular indentations just like the ones left in soft wood by an inept carpenter. The head of each nail has approximately the same surface area as Lake Champlain, and it seems certain that they *are* nails, of some sort, because their shafts rise partway out of the ground every morning, in response to the gravitational pull of Saturn's neighbor Jupiter, as if in yearning.



Michael Crawford

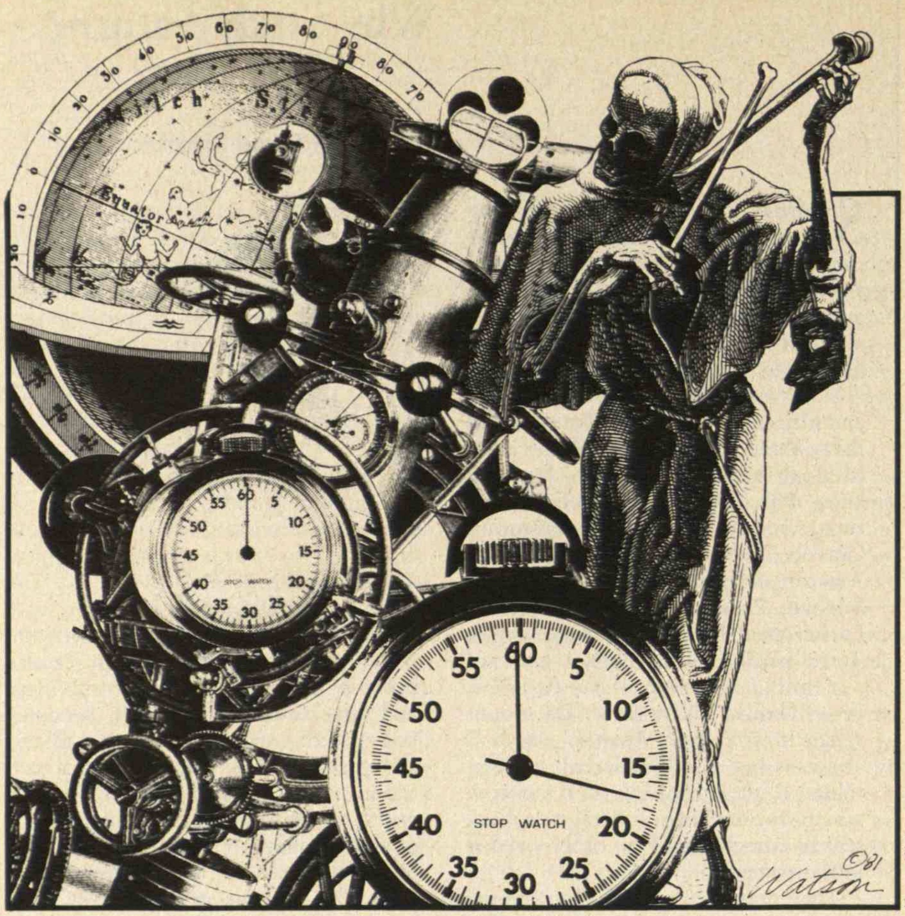
Saturn's atmosphere is a highly corrosive cloud cover of gasified nickel and cesium sublimate. Human teeth would evaporate in it in less than two seconds. From outer space it looks like a cool, nacreous liquid, but in fact it would scald away a mortal and his sins in the twinkling of an eye. If you stood on the surface of Saturn and searched the thick, gray vault above you for some sign of the sun, you might find it hanging up there like a dull dime or a pearl behind smoked glass, but it is far more likely that as your sins and teeth melted away you would not think about the sun at all.

Up close, Saturn's rings have proved such a disappointment that it might have been wiser to shut off the camera while the spacecraft punched through them. Flaked brass, ashes, hair, lint, floating patches of sunburned skin, sawdust, dandruff — every kind of filth and detritus imaginable. For the record, there are five rings — Ring R (the one closest to the planet), Ring I, Ring N, Ring G, and Ring S. Only Ring G is in any way remarkable; it is visible from Earth for a single week, in early March. Big deal. But oh the beauty and solemnity of the rings from afar — the symmetry, the balance, the processional majesty, the inevitability, the monumentality, the silence!

Why study Saturn? Because it emits a tremulous C in the mezzo range every evening at seven o'clock. Because you know it is always there when you need it. Because its name helps you remember the word "saturnine" in the middle of the night. Because it bears down on a high-magnification telescope like a cement truck. Because it has something that looks like a watch stem sticking out of its north pole. Because if you were big enough to try to pin it under your thumb it looks as if it would slip away from you like a globule of quicksilver. Because it is the best at what it does. Because of the rings!

Daniel Menaker is an editor of The New Yorker, *where this piece originally appeared. It is reprinted by permission;*

The Soul in the Machine



Karen Watson

Ethics in an Age of Pervasive Technology
Melvin Kranzberg, ed.
Boulder, Col.: Westview Press, 1980, 246 pp., $25

Reviewed by Judith Wagner DeCew

In December 1974, an international symposium known as the Wunsch Conference was held at the Technion, the Israel Institute of Technology. This volume contains the presentations of humanists, social scientists, lawyers, engineers, and natural scientists who gathered there to examine the role of ethics in a world of pervasive technology. Clarification of the novel problems brought on by technological advance, and thoughtful assessment of alternative moral principles that address these issues, would be an important contribution. Unfortunately, this collection, augmented with only a few brief introductions and summaries of the papers, far from fulfills its promise that "the authors face the major political-religious-social issues of contemporary society."

Technology as Frankenstein's Monster

Despite some illustrious names familiar to Western academics, including sociologist Daniel Bell (Harvard), philosophers Isaiah Berlin (Oxford), Max Black (Cornell), Stuart Hampshire (Oxford), and scientists Walter Rosenblith (M.I.T.) and Alvin Weinberg (Oak Ridge), the papers are overwhelmingly disappointing. Many are extremely short or brutally edited and tend to obsure rather than clarify the central issues. Moreover, they provide little insight into such important topics as risk, responsibility, and obligations to future generations.

Instead, we are told in the very first essay that "anyone who looks seriously at the present predicament of humankind can see that we are heading, inevitably, toward disaster." We are repeatedly reminded of "the global problems of population" and "the degradation of the environment," and that "the arms race continues unabated." Technology is compared to a "cancerlike growth threatening human existence." We are chastised for being in "total disregard of real values" and are told that the scientific focus on methodology and unbiased analysis has led to the widespread conclusion that values are not the concern of scientists and technologists. The editor worries that "engineers have sought efficiency and cost-benefit effectiveness without considering human factors and social benefits and 'dis-benefits.'" Discussions of remedies for this dismal state vaguely and unconstructively employ terms such as "freedom," "transcendence," and "justice."

These overgeneralized and sometimes irrelevant, pessimistic, and preachy lectures do not help clarify which values are jeopardized by technological advance or even begin to suggest positive proposals. This is especially unfortunate because particularly intriguing claims — such as the general agreement that scientists and engineers have special responsibilities and that engineering education should, like law and medicine, include a study of values — remain empty without such clarification. Nevertheless, some crucial concerns about balancing interests and imposing limits do surface.

The conferees isolated several factors that make our current situation historically unique: the magnitude of today's problems, the complexity of unintended consequences, and the interconnectedness and universal scope of technological effects. These factors led some participants to question whether moral problems associated with technological development are soluble at all, and led others to argue less pessimistically that traditional Judeo-Christian ethics are inadequate to deal with such global dilemmas. I do not agree that "moral philosophy is underdeveloped, so much so that it has ignored the special problems posed by science and technology." Rather, the historical tension between public interests and individual rights is what must be addressed.

Unfortunately, this book leaves the impression that neither theories nor their implementations are being used to deal with current technological problems. This could not be further from the truth. American courts are currently deciding numerous cases arising from chemical and nuclear pollution, explosions, and dangerous products. While we generally think of private law as functioning to enforce individual rights, it is striking that decisions in these technology-related cases are overwhelmingly dominated by generally utilitarian arguments, focusing on overall public benefits and costs. Thus, for example, risks of pollution or explosion are legally wrong only when the costs of taking the risks (the damage caused multiplied by the probability of the damage) outweigh their benefits.

Utilitarian theory (requiring that choices be made according to the social and economic consequences of hazardous activities) may appear a natural one for defending reasonable technological growth but it is not. Some claim that because technological problems are often associated with actions of large corporations or political groups, the notion of moral fault is inappropriate. Moreover, it is increasingly difficult to make accurate assignments of moral blame in complex technological accidents. Thus, with the development of computerized production, nuclear power, supertankers, and modern biological research, it is compelling to agree with many judges and legal theorists that moral fault cannot be the basis of responsibility for technological problems, and that costs of accidents must be balanced against the consequences of limiting ourselves to more expensive or less pleasant but safer lifestyles.

It is also argued that society would be best served if technological enterprises carried the financial burden of responsibility as an incentive to develop ways to avoid the damage. Thus, public-policy arguments can supposedly strike an ideal balance — they can defend technological advance while encouraging precautions.

Several authors in this volume endorse this position, characterizing technology as the search for the useful. They suggest that its goal is the benefit of society, concluding that "ideally, industry should produce the greatest good for the greatest number of people."

Rights as Limits

But what contemporary moral theory emphasizes, and a few of these contributors recognize, is that weighing overall social benefit and harm, often done today in economic terms, cannot be enough. Overall benefit does not account for the plight of unfortunate individuals. Surely it is unreasonable to suppose that blowing innocent people to bits, or merely exposing a few to clear risks from pollution, "can be traded off against certain other kinds of gains" for the rest of society. We need "boundary conditions that are not to be transcended." The solution is to treat individual rights as "trumps," serving as absolute limits on what can be justified by social welfare.

The task is to determine exactly what our individual rights are. In the context of technological growth, it is crucial to ask whether we have a right to bodily security. If we do, is it implicit in our right to life? Does it mean we have a right to maximum security compatible with like security for everyone else? Does it give us a right to freedom from emotional harm (such as fear) as well as physical harm? Does it guarantee freedom from any degree or even remote risk of harm, even if the risk is unintentional?

Although a great deal remains to be worked out before we can answer these questions, it is clear that each of us does have such a right and that we must maintain it even at (perhaps great) economic and social cost. Hence, if the charge that engineers and scientists always take "the most simple, reliable, and economic solution" is correct, their censure is deserved. I believe the charge is too harsh and share Bell's optimism: "To the extent that people become more and more independent of nature, they can choose and construct the kind of society they want."

Judith Wagner DeCew is assistant professor of philosophy at M.I.T. and currently a fellow in law and philosophy at Harvard Law School. □

History Without Hindsight

John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death
Steven J. Heims
M.I.T. Press, 1980, 547 pp., $19.95

Reviewed by Freeman J. Dyson

John von Neumann and Norbert Wiener were great mathematicians deeply and passionately involved in the political and moral problems of their time. In this dual biography, Heims has done an excellent job of historical research; interviewing the friends and colleagues of his subjects, collecting their letters and studying their publications. He brings them vividly to life as human beings and explains lucidly in nontechnical language the themes of their professional work. He describes in detail the events of their public careers and the political opinions they expressed in public and private. Every fact and every quotation is carefully documented in 115 pages of bibliographical notes: so far so good.

If Heims had been content with this, that is, to present his work as a historical narrative with the protagonists speaking for themselves, he would have made an important contribution to the understanding of the great moral dilemma of our age. Unfortunately, he has embedded these biographies in a hortatory statement of his own opinions and prejudices. He stands at the front of the stage between his characters and the audience, making it difficult for us to hear their voices and to see the drama of their lives.

A Moral Dilemma

Wiener and von Neumann were admirably suited by temperament and circumstance to serve as spokespersons for the two opposing views that dominated the great debate over weapons and strategy after the end of World War II. Wiener came to believe that modern weapons in the hands of modern governments were an absolute evil, and that a morally responsible person should have nothing whatever to do with them. Von Neumann believed that the old political realities of national power and the tribal imperative of fighting for survival were inevitable even in a world of hydrogen bombs. The great tragedy lies in the fact that both these views contain a large element of truth.

But Heims denies the existence of a moral dilemma by proclaiming repetitiously that Wiener was right and von Neumann wrong. He robs the drama of its wider meaning by presenting von Neumann's beliefs as unfortunate side effects of a bourgeois upbringing. Dominated by the ideological cliches of the 1960s and 1970s, Heims fails to understand the 1940s and 1950s. I am not saying that history ought to be morally neutral, only that historians ought to understand before they condemn. Three examples of Heims' shortsightedness follow.

First, there is the moral decision that Weiner protested and von Neumann approved: the dropping of the bombs on Hiroshima and Nagasaki that marked the start of the nuclear age. Heims says flatly that "the primary consideration in dropping the atomic bomb on Japan in August 1945 had not been speeding the end of the war — the bombs were not necessary for that purpose, and the U.S. government knew that." If that statement were true, then there would have been no moral dilemma, and Truman would stand condemned as a liar as well as a mass mur-

derer. Heims quotes several secondary sources in support of this statement but does not refer to the primary source, Robert J.C. Butow's book, *Japan's Decision to Surrender* (Stanford University Press, 1954).

Butow is an American historian who spent several years in Japan soon after the surrender, examining Japanese state papers and interviewing extensively the surviving members of the wartime Japanese government. He came closer than any contemporary or future historian can come to answering the crucial question, "Would Japan have surrendered if the atomic bombs had not been dropped?" I asked Butow this question explicitly when he was visiting Princeton. Butow replied, "The Japanese leaders themselves do not know the answer to that question, and if they cannot answer it, neither can I." Butow went on to explain that the Japanese government in 1945 was delicately balanced between the civilian leaders who were trying to open peace negotiations through the Soviet Union and the military leaders who were preparing to defend every inch of Japanese soil with the same suicidal ferocity with which they had defended Okinawa. Even with the advantage of hindsight none of us can know which way the balance would have tilted if the bombs had not been used. Truman in 1945, without hindsight, and with the carnage of Okinawa fresh in his mind, could know even less. It is reasonable to condemn Truman's action, as Wiener did, but it is not reasonable to deny the historical circumstances of his action.

Second, there is the fact that von Neumann in the late 1940s and early 1950s advocated a preventive war against the Soviet Union. The phrase "preventive war" conveys today an impression of militarism gone mad. But to the generation that lived and suffered through the 1930s, the phrase had quite another meaning. It was widely held, especially by liberal intellectuals, that the French and British governments had behaved in a cowardly and immoral fashion when they failed to march into Germany in 1936 to stop Hitler from remilitarizing the Rhineland. A preventive war at that time, when Germany was still effectively disarmed and incapable of serious resistance against invading forces, might have overturned Hitler's regime in a few days and saved the 50 million human beings who were to die in World War II.

I am not arguing that a preventive war would have been either feasible or effective. But the idea of preventive war as a morally acceptable option was widely accepted by von Neumann's generation, which looked back to 1936 as a tragically missed opportunity. To them, the idea of forestalling a terrible catastrophe by bold preventive action was not inherently insane nor inherently criminal. Von Neumann argued in 1950 that America was facing the same choice that France and Britain faced in 1936, when the Soviet Union was just beginning to acquire nuclear weapons. Von Neumann saw this as the last chance for America to overthrow the Stalin regime, as 1936 had been the last chance to overthrow Hitler, without a war of annihilation. It is unlikely that preventive war could have achieved its objective at either time, but to discuss von Neumann's advocacy of preventive war without historical perspective is to miss the main point.

In Defense of Freedom

Finally, there is the question of "freedom," a word that hardly appears at all in Heims' book. In Heims' view, modern weapons and military establishments are instruments of enslavement, natural enemies of the independent, rational soul. Wiener expressed this view eloquently in his writings and his actions. Yet one cannot begin to understand the deep involvement of American scientists in military technology if one does not examine the contrary view, that freedom and military inventiveness are naturally allied.

Von Neumann's generation saw free societies obliterated all over Europe, not by internal forces of oppression but by Hitler's armies. Freedom survived in England in 1940 because the coastal radars and the fighter airplanes were there when needed. Many people at that time believed that freedom was made possible by the willingness of British and American scientists to apply their skills wholeheartedly to the problems of war. Even Wiener shared this belief in the 1940s, when he worked enthusiastically on the improvement of antiaircraft fire control. After Hiroshima, Wiener changed his mind, but the majority of American scientists did not.

The experience of World War II left behind a widespread feeling that a permanent alliance between freedom and military science was right and proper. The alliance was evidently beneficial to both parties: a free society needed superior military technology to withstand the superior discipline of a totalitarian enemy, and the military establishment needed a free society to enable scientists and soldiers to work together in an informal and creative manner. In the context of the Soviet-American arms race, the free scientists of America would always carry a responsibility to stay ahead in the quality and variety of their inventions to compensate for the larger military expenditures and secrecy of the Soviets. This doctrine may be naive and old-fashioned, but it dominated von Neumann's thinking and still flourishes today in Israel and even some regions of America. When Heims writes of von Neumann and the arms race without discussing the notion of "fighting for freedom," that grand illusion at the root of the modern tragedy, he is plowing a shallow furrow in the rich soil of history.

Poets sometimes capture the prevalent mood of an epoch more precisely than scientists or historians. Cecil Day Lewis did so in his epic *The Nabara*, the greatest poem of the Second World War, written in 1938. *The Nabara* is a dirge for the crew of an armed trawler sunk in the Spanish Civil War. It is also a hymn of praise to the human spirit that continues fighting for freedom, stubbornly and unreasonably, against hopeless odds, preferring to die rather than to surrender.

They bore not a charmed life. They went into battle foreseeing
Probable loss, and they lost. The tides of Biscay flow
Over the obstinate bones of many, the winds are sighing
Round prison walls where the rest are doomed like their ship to rust —
Men of the Basque country, the Mar Cantabrico . . .
For these I have told of, freedom was flesh and blood — a mortal
Body, the gun-breech hot to its touch: yet the battle's height
Raised it to love's meridian and held it awhile immortal;
And its light through time still flashes like a star's that has turned to ashes,
Long after Nabara's passion was quenched in the sea's heart.

Lewis's poem is a dirge not only for the 52 fishermen but also for all of us who believe in freedom and have chosen to defend it with the technologies of death.

I have criticized Heims harshly for his

undervaluing of the moral impulses that drive the arms race. Now I would like to mention the two passages most illuminating in his book. They show the author's awareness of the importance of myths and symbols in human affairs. Von Neumann and Wiener frequently quoted two stories, each a literary archetype, a theme song illustrating a particular aspect of human destiny. Von Neumann's theme was the Melian dialogue of Thucydides, the classic argument between an arrogantly oppressive empire and a defiant city resolved to defend itself to the death. Wiener's theme was the W.W. Jacobs story of the monkey's paw, the magic talisman that fulfills human wishes but always in such a way as to bring grief to the wisher.

Freeman J. Dyson is professor of physics at the Institute for Advanced Study at Princeton. His most recent book is Disturbing the Universe *(Harper & Row, 1979).* □

THE LEADING EDGE

#1 in a series of reports on new technology from Xerox

About a year ago, Xerox introduced the Ethernet network—a pioneering new development that makes it possible to link different office machines into a single network that's reliable, flexible and easily expandable.

The following are some notes explaining the technological underpinnings of this development. They are contributed by Xerox research scientist David Boggs.

The Ethernet system was designed to meet several rather ambitious objectives.

First, it had to allow many users within a given organization to access the same data. Next, it had to allow the organization the economies that come from resource sharing; that is, if several people could share the same information processing equipment, it would cut down on the amount and expense of hardware needed. In addition, the resulting network had to be flexible; users had to be able to change components easily so the network could grow smoothly as new capability was needed. Finally, it had to have maximum reliability—a system based on the notion of shared information would look pretty silly if users couldn't get at the information because the network was broken.

Collision Detection

The Ethernet network uses a coaxial cable to connect various pieces of information equipment. Information travels over the cable in packets which are sent from one machine to another.

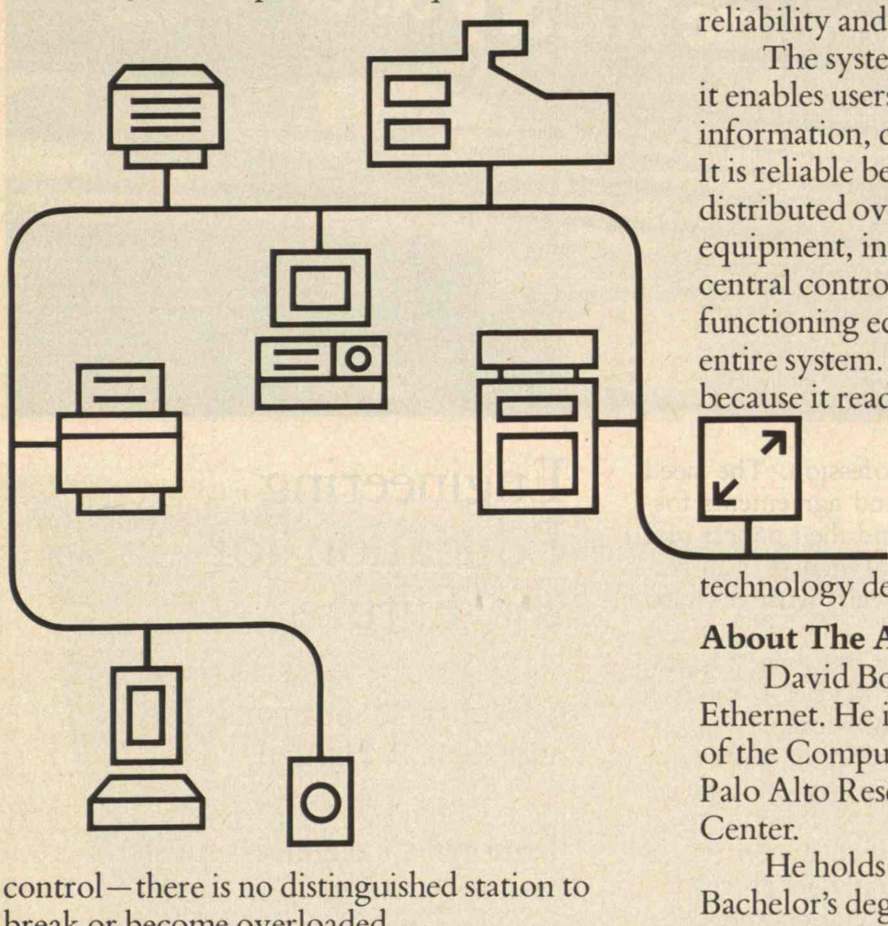
A key problem in any system of this type is how to control access to the cable: what are the rules determining when a piece of equipment can talk? Ethernet's method resembles the unwritten rules used by people at a party to decide who gets to tell the next story.

While someone is speaking, everyone else waits. When the current speaker stops, those who want to say something pause, and then launch into their speeches. If they *collide* with each other (hear someone else talking, too), they all stop and wait to start up again. Eventually one pauses the shortest time and starts talking so soon that everyone else hears him and waits.

When a piece of equipment wants to use the Ethernet cable, it listens first to hear if any other station is talking. When it hears silence on the cable, the station starts talking, but it also listens. If it hears other stations sending too, it stops, as do the other stations. Then it waits a

random amount of time, on the order of microseconds, and tries again. The more times a station collides, the longer, on the average, it waits before trying again.

In the technical literature, this technique is called carrier-sense multiple-access with collision detection. It is a modification of a method developed by researchers at the University of Hawaii and further refined by my colleague Dr. Robert Metcalfe. As long as the interval during which stations elbow each other for control of the cable is short relative to the interval during which the winner uses the cable, it is very efficient. Just as important, it requires no central control—there is no distinguished station to break or become overloaded.



The System

With the foregoing problems solved, Ethernet was ready for introduction. It consists of a few relatively simple components:

Ether. This is the cable referred to earlier. Since it consists of just copper and plastic, its reliability is high and its cost is low.

Transceivers. These are small boxes that insert and extract bits of information as they pass by on the cable.

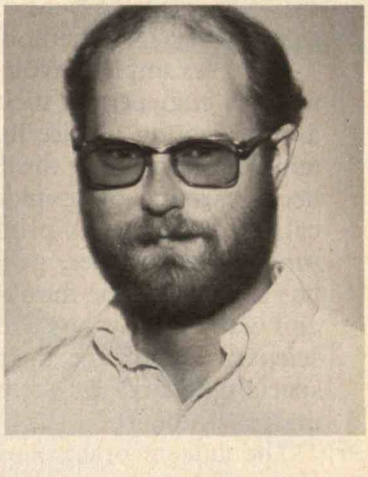
Controllers. These are large scale integrated circuit chips which enable all sorts of equipment, from communicating typewriters to mainframe computers, regardless of the manufacturer, to connect to the Ethernet.

The resulting system is not only fast (transmitting millions of bits of information per second), it's essentially modular in design. It's largely because of this modularity that Ethernet succeeds in meeting its objectives of economy, reliability and expandability.

The system is economical simply because it enables users to share both equipment and information, cutting down on hardware costs. It is reliable because control of the system is distributed over many pieces of communicating equipment, instead of being vested in a single central controller where a single piece of malfunctioning equipment can immobilize an entire system. And Ethernet is expandable because it readily accepts new pieces of information processing equipment. This enables an organization to plug in new machines gradually, as its needs dictate, or as technology develops new and better ones.

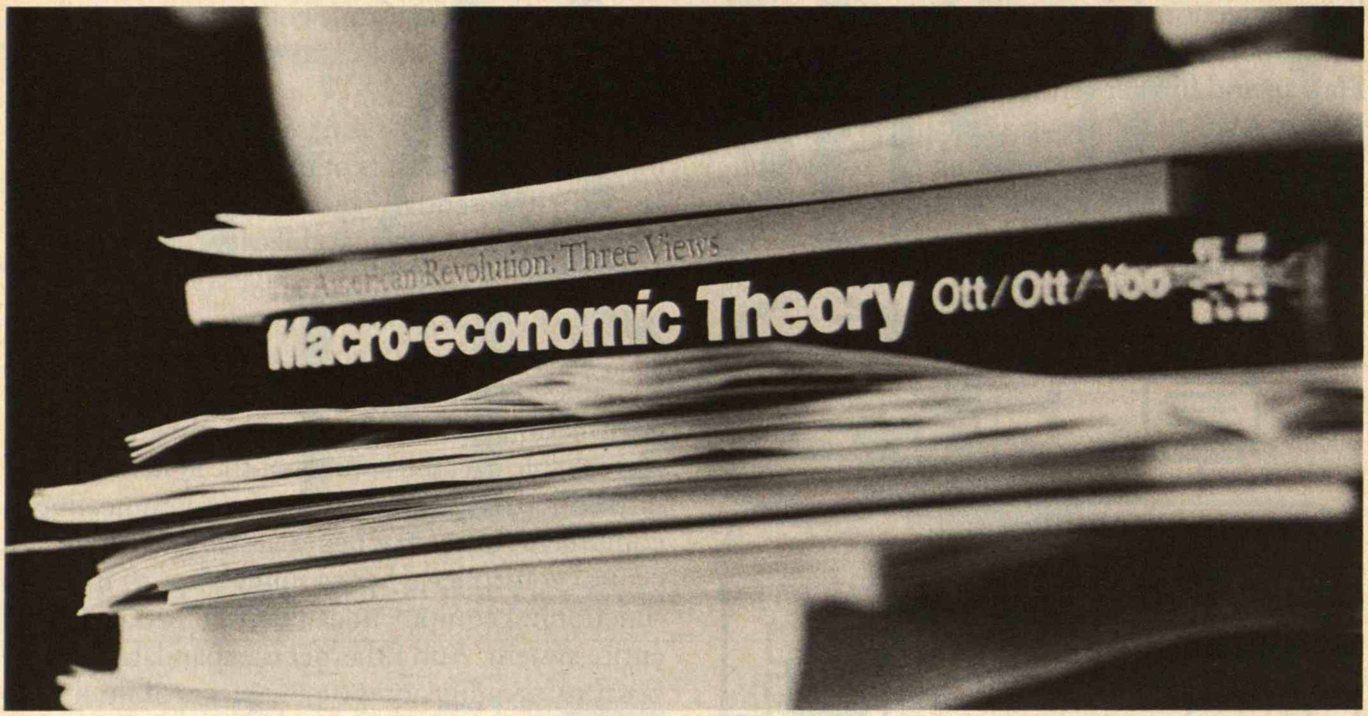
About The Author

David Boggs is one of the inventors of Ethernet. He is a member of the research staff of the Computer Science Laboratory at Xerox's Palo Alto Research Center.



He holds a Bachelor's degree in Electrical Engineering from Princeton University and a Master's degree from Stanford University, where he is currently pursuing a Ph.D.

XEROX



Engineering Education for the Future

by Robert C. Seamans, Jr. and Kent F. Hansen

Tomorrow's engineers must be responsive to new social needs as well as to new technological opportunities.

Engineering is an ancient profession. The need to record communications and agreements fostered the invention of papyrus and then paper: raw materials were processed into a new form with certain desired characteristics. Concern with the passage and measurement of time led to the invention of water clocks, sun dials, and other timepieces, representing the development of new devices to meet a social need. As societies grew more complex, problems regarding housing, transportation, and food led to the development of roads, irrigation systems, and construction methods.

These examples involve all the characteristics of modern engineering, including materials processing and utilization, device invention, and complex system development — the effort to respond to societal needs through the exploitation of physical, chemical, and biological principles, resulting in useful products, structures, processes, and services. What has changed in the thousands of years since papyrus and water clocks, however, is the broadened base of scientific knowledge, the proliferation of engineering specialties, and the systematic education of engineering practitioners.

The ancient practitioners of engineering worried about the education of their disciples much as we do today. Vitruvius, often cited as the main source of our knowledge of ancient times, wrote of his con-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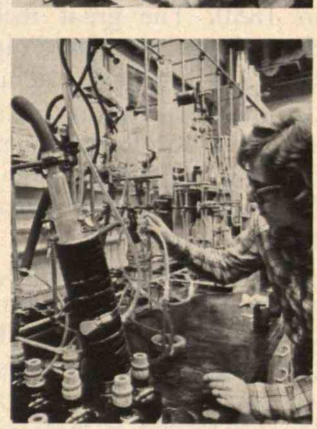
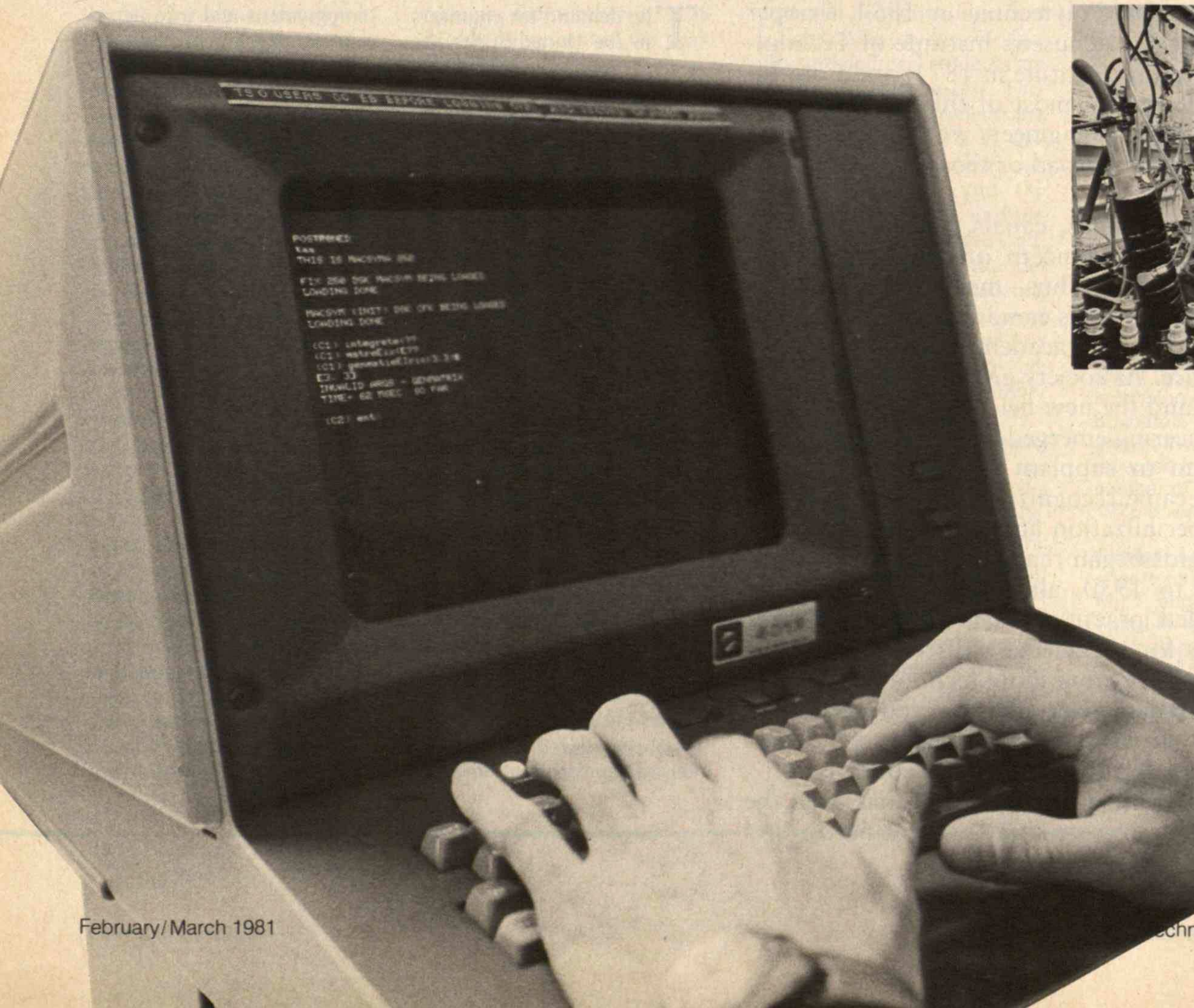




cerns about education and the need for both theory and practice over 2,000 years ago. By the Renaissance, engineering had become part of academia: Galileo was a professor of physics and military engineering at Padua. The coupling of engineering with the military led to the first school of engineering, the Ecole des Ponts et Chaussés, founded in 1747 in Paris as a training school for military engineers. The U.S. Military Academy at West Point was established in 1802 to train officers for the Corps of Engineers; it did not become a general military academy until after the War of 1812. However, military needs and civil needs were so similar that nonmilitary engineering programs also appeared during the same period. In France, the Ecole Polytechnique was begun in 1794, and in the United States, the Rensselaer Polytechnic Institute was founded in 1824.

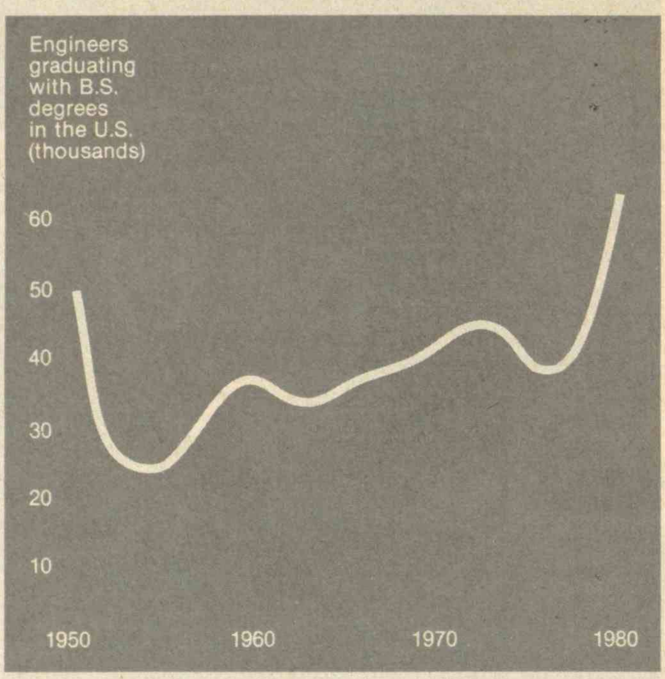
Engineering as an academic discipline grew throughout the mid-nineteenth century. Harvard University introduced engineering in 1847 and Yale in 1850. The great technical institutes followed thereafter: Brooklyn Polytechnic in 1854, Cooper Union in 1859, Massachusetts Institute of Technology in 1861, Stevens Institute in 1871, and Case Institute in 1880. During most of this time, indigenous, university-trained engineers were outnumbered by engineers trained abroad or those who were self-taught.

The building of roads, canals, bridges, and railroads was the main concern of these nineteenth-century practitioners. Thus, most engineers were civil engineers; their skills came from trial and error and a close link between academic training and professional practice. As society grew more technologically complex and the new fields of mechanical and electrical engineering emerged, academically trained engineers began to supplant the self-taught ones. Engineering became recognized as an academic discipline, and specialization and the consequent proliferation of fields began that continues to this day.

From 1850 to 1950, although the objective of providing skilled practitioners remained, the fundamental basis for knowledge shifted from experience to science. More and more technological training involved mathematics, physics, and chemistry, and an attempt at *understanding* began to supplant *experience* as a basis for engineering education.

The unifying context of engineering has been the exploitation of science to meet societal needs, and

How Engineering Enrollments Reflect Students' Perceptions of the Future Society



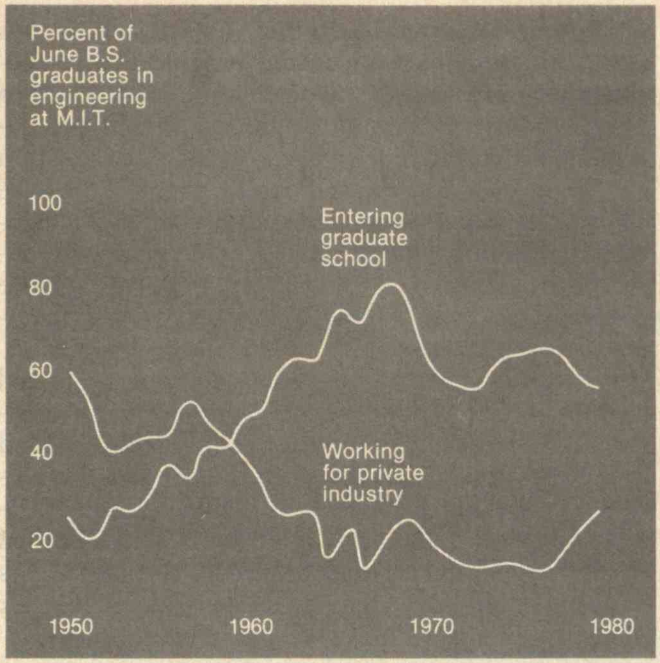
The demand for engineers in the United States has recently reached record highs, as reflected in the number of job openings as well as the salaries offered. Furthermore, this period of high demand is as long as any in the last 20 years, with no clear end in sight. The causes include the high level of federal and private-sector spending on energy technologies, the need for improved environmental controls, continued high defense spending, continued growth of computer technology and its applications, emerging new technologies such as genetic engineering, and the reaction of industrial organizations to the challenge of foreign competition.

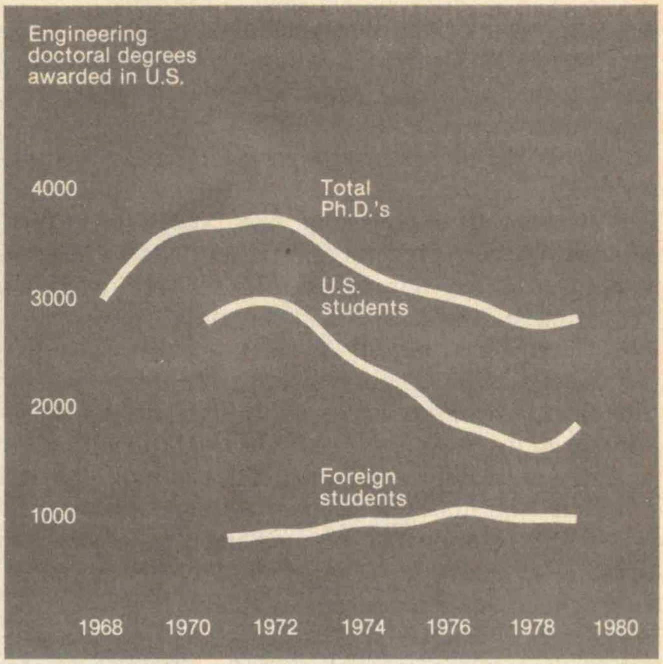
Young people are well aware of the opportunities in engineering, and enrollment trends reflect their perceptions (*see the left chart, above*). When engineering has been viewed as a rewarding career with high levels of employment and income potential, enrollments have increased. Conversely, when opportunities have been limited, enrollments have fallen.

The number of graduates was over 50,000 a year five years after the end of World War II, but only with a 40 percent increase in the graduation rate from 1976 to 1979 has the number returned to the postwar level. The most recent data suggest that engineering enrollments are leveling off at a rate of nearly 60,000 bachelor's graduates per year.

Graduate School or Job?

From 1950 to 1970, an increasing proportion of bachelor's engineering graduates chose graduate school instead of employment in industry for their immediate postgraduate activity. Then in the late 1960s and early 1970s there was a rapid turnaround. Although the draft





status of students changed in 1968, many students were apparently disillusioned with technology and elected to leave the profession, often to seek careers in law and medicine. The recent reduced interest in graduate school is probably the result of the expanding job market and the high costs of education. The percentage of graduates going into industry is now increasing, presumably for the same reasons.

As a direct result of the decline in graduate enrollment, the number of students continuing to receive doctor's degrees is shrinking, as shown in the chart at the right. The number of doctorates in engineering has dropped by about 25 percent from the peak in the early 1970s. Today, between 35 and 40 percent of the doctorates in engineering are given to foreign students. The large drop in doctorates given to American students is distressing: the number in 1978 is only 56 percent of the peak in 1972.

New Faculty Scarce

Most domestic engineering students find that the cost of graduate education is not reflected in higher lifetime earnings. Also, the path to executive positions in industry appears to depend less on a graduate degree in engineering than a master's degree in business administration. Finally, the demand for doctorates from students interested in teaching has decreased because salaries for teachers appear less attractive, even including part-time consulting, than those for careers in industry.

The drop in enrollment at the doctoral level will have far-reaching and damaging consequences unless the trend is reversed. All fields require research for a better understanding of fundamentals and potential new directions, and collaborative studies by faculty and doctoral students are the key to this process. Faculty and doctoral students are also the collators and disseminators of new knowledge through teaching and the publication of books and papers. Research is already adversely affected by the decrease in doctoral students, and the availability of new faculty will be even more at a premium in the future because of the limited number of suitable candidates.

The engineering programs at many institutions last underwent major reform in the late 1940s and early 1950s, the beginning of the dramatic emphasis on graduate education. Today, society requires a wide spectrum of engineering types, and engineering education should reflect the wider range of responsibilities. — *R.C.S., K.F.H.* ☐

Far left: A trough occurred in the number of engineers graduating with bachelor's degrees in the U.S. in 1954. As the marketplace in industry, government, and universities improved, enrollments and the number of graduates increased markedly. Except for a small recession in the early 1960s, the trend was upward until the early 1970s. Enrollment began to decline in the late 1960s because of the drop in employment opportunities and concerns about the Vietnam War and technology in general. Educators then began to see growth in enrollments as reflected in increases in the number of graduates from 1976 onward.

Center: As high-technology opportunities increased, many M.I.T. engineering graduates opted for graduate study beginning in 1960.

Right: A recent decline in advanced degrees is attributed to an increasingly active job market for engineers with bachelor's degrees.

There is a growing need for truly innovative technical approaches that satisfy economic and social issues to an unprecedented extent.

this drive for development is fundamental to civilization. Society's perpetual needs for communication, transportation, health preservation, security, and nutrition provide continual impetus to engineers to search for improved or alternative applications.

This view of engineering as a "reactive" profession, in which practitioners respond to demands with their skills, ignores another important aspect, the creative aspect, in which new developments precede perceived needs. A classic example is the airplane, which was not a direct response to the need for a new form of commercial transportation or national security. Orville and Wilbur Wright were simply motivated to be the first to fly a heavier-than-air craft under its own power. Yet within a few years of its discovery, the airplane was adapted to both these needs.

One could also point to the camera, the telephone, and the phonograph as creative, not responsive, technological developments. There was no attempt by inventors to improve on what existed or to provide an alternative based on new science. Rather, creators produced new technologies in their quest for innovation, and these technologies fostered a variety of new societal needs. This aspect of engineering remains important and deserves careful nurturing.

The Contemporary Milieu

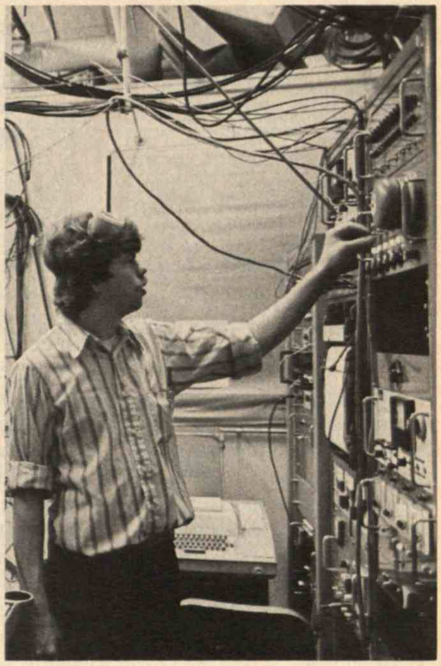
Because engineers are at least somewhat responsive to social needs, they will clearly continue to contribute to social developments. For example, our need for transportation vehicles and systems is increasing rather than diminishing. In fact, a great deal of excellent engineering has resulted from applying new science to transportation problems, as well as from progressive improvements in vehicle design. Similar developments have been made in the fields of communications, data processing, and food processing.

In view of this continuing growth of societal needs, some observers feel that engineers have failed; that technology has brought society to a complexity beyond our ability to manage and sustain it. However, each improvement brings an increase in societal expectations. For example, the automobile developed from a rich person's toy into everyone's necessity. The continued demand for improvement in safety, comfort, and economy has been the stimulus for constant engineering evolution. With widespread use of cars, the inadequacy of the road network became apparent, resulting in demand for improved streets. Vehicle congestion changed cities and made possible the surge to the suburbs, which also created new pressures for highway development and improvements in the automobile. Pollution and smog from the automobile in our urban communities forced stringent environmental regulations.

Similarly, new food technologies have allowed more abundance but have deeply affected the environment; health-care developments have created new problems for dealing with the aged. Transportation technology has so improved within a few decades that almost all parts of the globe can be reached within hours, and travel for business and pleasure is not only rapid and safe but relatively affordable for many people. The results of this revolution are increased pressure on local authorities for improved airports and the myriad services that travelers require. Thus, each municipality has to serve not only local needs but those of the large number of transients.

We do not foresee a new set of social functions arising for engineering; rather, we see new problems within the profession's traditional areas of concern. The mismatch of expectations and actual technological performance has given rise to deepening moral concern about the use of technology, exacerbated by two additional factors: the increasing complexity of our society, owing partly to the successes of technology; and the expanding scale of activities that has brought us noticeably closer to limitations in natural resources and waste disposal.

One example of social complexity involves the communications media, with telephone and television links now providing instantaneous contact among people and places worldwide. These communications developments have led to vastly expanded coverage of world news such that people are informed of events as they occur, with enormous effects. Many have argued that the dramatic coverage of the Vietnam War on American television played a major role in turning public opinion against U.S. involvement. Similarly, politicians argue that television coverage of election returns in the East influences voters in Western states. These developments in communications technology have created



vast new problems for maintaining individual privacy.

Limitations on resources have occurred in the past: the denuding of the Mediterranean littoral for firewood is one extreme example. Resources in short supply today include high-grade metal ores, fresh water, arable land, natural gas, and petroleum. There are also existing or impending problems in the disposal of byproducts from industrial societies: waste heat from power plants, carbon-dioxide emissions from combustion, chemical wastes, and — the most controversial — waste from nuclear reactors.

The public has observed these technological impacts and is questioning societal values and goals to an unprecedented extent, protesting against power plants, refineries, pipelines, and highways. Indeed, the environmental movement partly reflects dissatisfaction with the goal of economic progress that characterized the past. Even more poignant conflicts arise over research into recombinant DNA, involving not only adequate safeguards but also the propriety of knowledge itself. Such technology-induced complications can be found in almost all fields: automation and employment, pesticides and long-term health, energy production and environmental impacts. Policymaking, decision making, and technological advance become increasingly complicated as the area of influence grows, and the practice of engineering will be profoundly influenced by this interaction.

Some of our present problems and new goals are reactive: problems created by one technology must be addressed or ameliorated with another technology. Other situations call for creative engineering, particularly for continuing innovation, for most economists agree that our national economic health is strongly dependent upon the invention of products and processes to compensate for our deficiencies in natural resources. There is a growing need for truly innovative technical approaches that satisfy economic and social issues to an unprecedented extent. The future of engineering, and thus the directions for engineering education, will be strongly influenced by these forces.

Engineering Branches Out

Formal programs in engineering education were created because society needed people trained in the practical application of certain arts. This view prevailed for about 150 years: there was a continual deepening of scientific knowledge, and this strongly influenced the development of technology through the flowering of engineering disciplines such as fluid dynamics, thermodynamics, and structural mechan-

Universities and Industry Bring Their Acts Together

by Nam P. Suh

The role of U.S. engineering colleges in advancing industrial innovation and productivity will be significantly strengthened with the recent enactment of the Wydler-Stevenson Technology Innovation Act of 1980. The act legislates the establishment of offices in the Department of Commerce and the National Science Foundation to promote cooperative research between nonprofit organizations and industrial consortia, especially to stimulate innovation in American industries with individual firms too small to provide major research funding. The consortia are intended to bring companies together without compromising competitive incentives.

Cooperative research is not a panacea for all the problems that have contributed to the recent slow rate of industrial innovation in the United States. However, the concept addresses two central issues in stimulating innovation: the generation of ideas based on fundamental understanding of nature, and the education of creative people. In both respects the M.I.T.-Industry Polymer Processing Program, the oldest of four cooperative ventures at M.I.T., has made important contributions to our educational efforts in polymer engineering and also to industrial technology. A large number of students have been educated in polymer engineering; some are now working in the industry and others are now teaching at other leading universities.

Research has led to a new discipline of nondestructive testing of polymeric parts and composites and many ideas for products and processes embraced by the industry. Licenses for the use of patents and other research results are assured to all member companies, for whom there are also important intangible benefits. Indeed, this pioneering program was used as a model in drafting the Wydler-Stevenson Act.

Merging Production and Education

Cooperative research can be justified only when its objectives are compatible with long-term goals of both educational institutions and industrial firms. Universities have three major institutional goals: education, the advancement of knowledge, and public service. Industry's goals include the production of goods and services, the realization of an adequate return on investment, and public service.

Universities traditionally have difficulty initiating new academic programs and disciplines even when society's needs change; the tendency is to continue what has been done in the past. Also, academic institutions' heavy dependence on federal research support biases their programs to emphasize prob-

ics. In this era, society needed two types of engineers: "practicing" and "entrepreneurial." Engineering education attempted to provide the first type through a four-year professional education that included elements of science — particularly physics, mathematics, and chemistry — and thorough training in the engineering disciplines, with the emphasis shifting among analysis, synthesis, and design according to societal needs. The task of teaching entrepreneurial engineers who would be the inventors and promoters of the profession was left chiefly to chance.

Technological developments during World War II suggested that less structured education produced more flexible and creative technologists, and engineering education began to emphasize the natural sciences and mathematical analysis. Large numbers of postwar graduates were absorbed into society as a new kind of engineering scientist, and their contributions to communications and control, chemical and nuclear engineering, and materials science paved the way for fundamental social changes. This view of the overriding importance of science prevailed until recently, when new societal forces and constraints began to be perceived. Today, engineering education is in a fluid state, with widespread conviction that changes should be made.

Society will continue to need well-trained engineering scientists, practicing engineers, and entrepreneurial engineers, and their education must accommodate the changing demands. In addition, two new engineering types will be needed: the systems engineer and the management engineer. The word "systems" can be used to describe a sphysical entity composed of many different elements, such as an aircraft system that includes the airframe, power plant, hydraulic actuators, instruments, and radio, but we use the term more broadly. The systems engineer must understand not only all internal interactions of an aircraft but also its external interfaces with the outside world.

Systems engineers must account for the performance of the ground crew, communications with air-traffic control, the effect of gusts and turbulence, passenger flow, cargo handling, the impact on the community of aircraft engine noise and air pollution, and national and international regulations during design, test, inspection, and operation. They must see the aircraft as one element in a broader, more encompassing transportation system. In other words, systems engineers must be students of technology and human affairs; they are the conscience of industrial and government enterprises. Management engineers, on the other hand, must be concerned with specifications, costs, schedules, tooling, purchasing, financing, and personnel — all the mana-

lems of the public sector over those of the private sector. Cooperative research provides the needed industrial component.

Industrial firms also have difficulties to which university research can be responsive. Most small firms lack the resources for research of any kind, especially the necessary multidisciplinary base to accomplish the extraordinary, so people in industry often depend on trial-and-error to solve their problems. Furthermore, many industrial managers base research decisions on short-term return-on-investment criteria, making only limited commitments to long-range, high-risk, but potentially high-return research projects.

In the case of cooperative research, the academic multidisciplinary research base can complement industrial expertise in solving problems, while industry can be a friendly skeptic and critic of a university research team working on industrial problems. Cooperative research can also provide stimulation to industrial engineers by providing new points of view, and the enthusiasm of young people can be contagious, even to the experienced and wise.

Solving Imaginative Problems

Cooperative research is not without problems. For example, the needs to publish and to maintain an open campus are not completely compatible with the competitive conditions in many industries. At M.I.T., we minimize these problems by filing patent applications early and delaying publications when necessary. Our program has also established long-term goals that generate short-term results to accommodate the industrial payback cycle.

The uncertain outcome of cooperative research that emphasizes innovation can pose risks to doctoral candidates. Universities usually encourage students to choose research problems that are already well defined, and not all industrial problems fit this pattern. Basic reform of engineering education will be required to deal with this situation.

Because the United States cannot, and perhaps should not, adopt the close relationship between the public and private sectors that characterizes some countries, we must explore our own means of strengthening the private sector. Cooperative research is one such means that should be judiciously promoted.

Nam P. Suh is professor of mechanical engineering at M.I.T. and director of the Laboratory for Manufacturing and Productivity. He has also directed the M.I.T.-Industry Polymer Processing Program since its inception in 1973. □

gerial factors required to design and produce products such as aircraft, automobiles, power plants, and home appliances.

Educational programs must be responsive to the future needs for all types of engineers. Engineering education must continue to graduate highly trained, scientifically oriented engineers, particularly in rapidly evolving areas such as biotechnology, synthetic fuels, materials, and computers. At the same time, we must prepare engineers to meet the new managerial and systems needs. Although the five types of engineers have much in common, a variety of institutional changes are required to serve their distinctly different needs.

The engineering scientist will require graduate training and frequently a doctorate. The undergraduate education for this type of engineer should emphasize the natural and engineering sciences, structuring knowledge in the most fundamental way for a broad, general education. However, pressures on faculty members make it difficult for them to create the structures for incorporating the vital new knowledge into the curriculum. Furthermore, after synthesizing a curriculum, faculty members need support to write the necessary textbooks. Therefore, the most important administrative contribution toward improving the quality of the engineering scientist is support of the faculty in writing textbooks and reference books that update and enliven teaching. Of course, all other types of engineering students will also benefit from this endeavor.

Teachers Contact Industry

The education of engineering practitioners will require changes at three levels of undergraduate education: subject content, faculty, and the structure of degree programs. Emphasis on engineering science has led to a reduction in the number of design subjects engineering undergraduates are required to take. To increase the productivity of American industry, product design, production engineering, quality assurance, quality control, and principles of manufacturing and production must be emphasized. The return to many hours spent over a drafting board is not advocated. Rather, design subjects should reflect future industrial practice, with emphasis on computer-aided design and computer-aided manufacturing. Design subjects can become one of the most interesting and challenging experiences of undergraduate engineering education.

Changes in faculty characteristics are more challenging. Most faculty are themselves graduates of the era of engineering science, with little industrial experience. How can they modify curricula to provide industry with experienced practitioners?

The mismatch of
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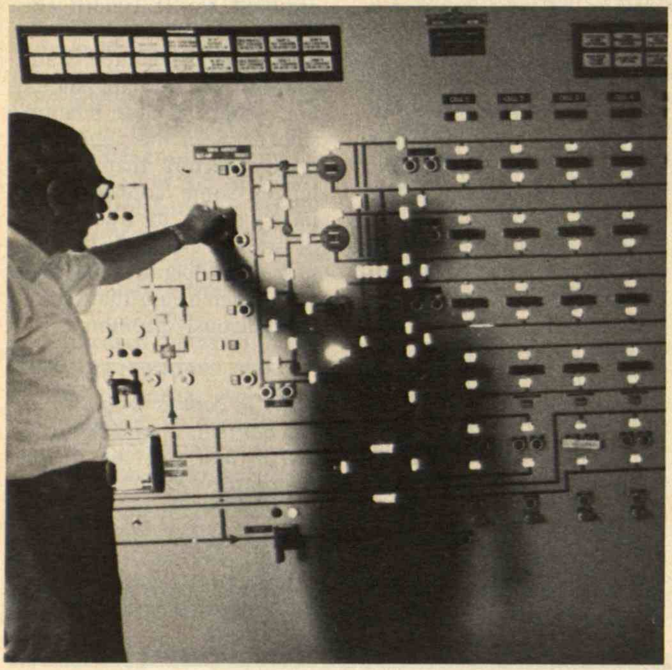
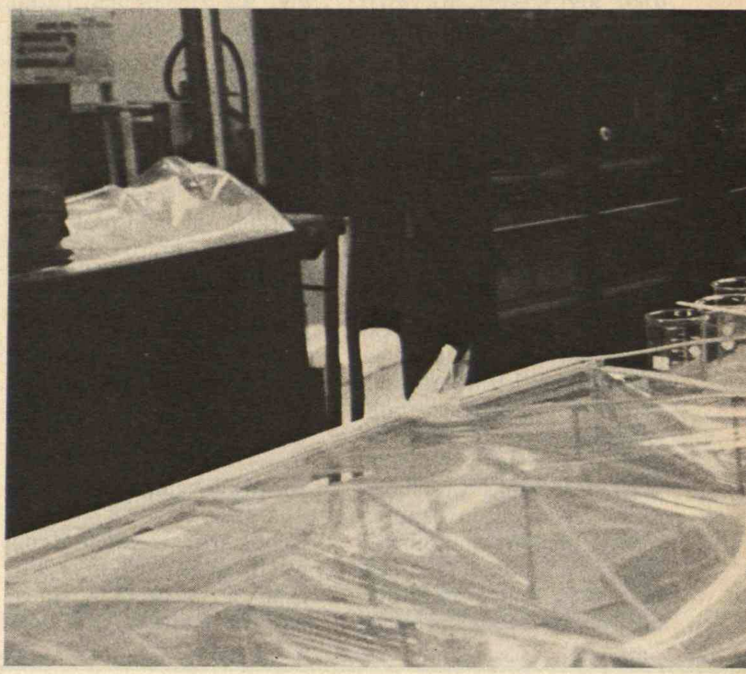
technology.





First, faculty should be encouraged to work with industry as summer employees and consultants and through sabbatical leaves. New junior faculty can be recruited from the ranks of industry, and recent graduates interested in teaching careers could take a postdoctoral year in industry. We have found considerable industrial interest in such programs at M.I.T. Indeed, some industries not only provide postdoctoral employment but are willing to continue close collaboration with junior faculty members after they return to campus.

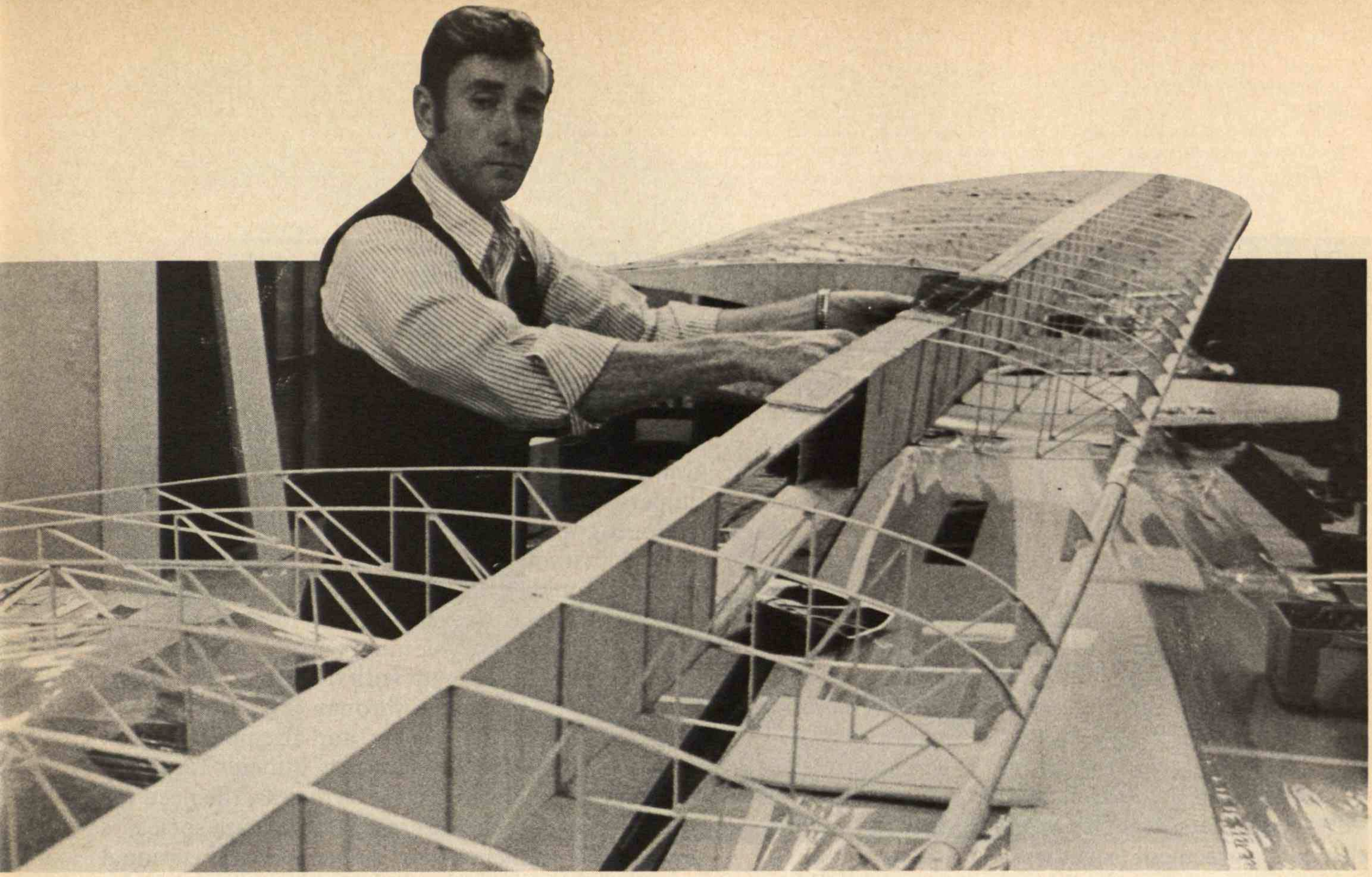
Adjunct professors primarily employed by industry or government can provide important inputs by teaching courses, conducting seminars, and supervising theses, although universities are slow to take advantage of this outstanding opportunity. Retired engineers are another source of professional experience invaluable in teaching as well as the construction of new curricula. But these efforts cannot alone give students a taste for the environment of professional practice; they must also work in industry. Hence, cooperative education should be the standard path for those who wish to become practitioners.

The Electrical Engineering Department at M.I.T. has had such a cooperative program with industry for nearly 65 years, in which students work for a company during the summers following their sophomore, junior, and senior years. These students prepare theses under faculty supervision as part of their corporate experience, and at the end of five years receive both a bachelor's and a master's degree. A similar internship program has been initiated in other engineering departments, with about 400 M.I.T. undergraduates enrolled in some form of cooperative program. Curriculum planners should deliberately extend their programs into the summer and allow sufficient flexibility to provide for a variety of off-campus experiences.

Graduate programs for practitioners belong in a special category. It is important that engineers be kept abreast of the rapid advances in scientific knowledge and new technologies, and therefore the most important form of graduate education may be continuing education. Because competition for new bachelor's graduates is intense in all engineering fields, an important element of corporate recruiting is the opportunity for advanced education after employment. This demand from industry represents both an opportunity and a challenge for engineering schools already carrying a heavy teaching load.

The Entrepreneur and the Manager

Individuals planning careers creating new technical industries or managing existing industries will re-



quire extensive knowledge of engineering and some understanding of marketing, banking, finance, accounting, and government regulation. Such managerial engineers should follow an undergraduate program only slightly different from that of practitioners. Although it may be possible to package all the necessary subject matter into an undergraduate program through careful structuring of electives, these engineers will benefit greatly from graduate study. Only truly exceptional individuals can gain solely in an undergraduate program the deep understanding of science, the conversion of science to technology, and the nontechnical issues of production and marketing necessary for success.

Graduate studies in this area should be geared not only to recent bachelor's graduates but also to practitioners with five to ten years' experience who are beginning to take on management responsibilities. Such graduate programs related to entrepreneurship and technological management are growing rapidly: there were 16 master's programs in 1970; by 1977, 41; and by 1979, 70.

In some cases, the most attractive graduate program for these engineers is a professional engineer's degree that allows time to acquire the needed breadth and depth. There is also room for a substantial thesis experience but without the research emphasis of the doctorate. Departmental or perhaps interdepartmental programs could be created to meet the needs and objectives of these special students.

Engineers Adapt to Nontechnical Environments

The most difficult and controversial educational challenge involves developing systems engineers; the technical community is concerned that programs encompassing sociology, economics, and political science lack professionalism and are of passing interest. However, societal concerns with technology will only increase, and it is not just prudent but necessary that engineering educators respond to these new conditions.

Most undergraduate engineering programs devote about 25 percent, or eight subjects, to the humanities and social sciences. In addition, almost all bachelor's programs have four to eight electives, although these are usually technical subjects. Thus, devising a coherent program in written and oral communications, historical and social perspectives of science and technology, ethics, and governance, control, and regulation in a democratic society is possible, although including this broad range of material may require a reduction of students' options. Educators need not shy away from asserting such authority if enrollment in the program is voluntary.

The systems engineer is likely to practice the profession in an environment different from that of the practitioner and entrepreneur — possibly in a government agency, public-interest organization, law firm, or international agency. Students should use their three available summers to gain experience as interns in a variety of such agencies, and engineering educators themselves should take responsibility for assuring that these opportunties are available and productive.

Many engineering students enter professional training full of enthusiasm and intensity for science, treating mandatory humanities requirements as unwelcome intrusions into their pursuit of scientific knowledge. It is small wonder that they do poorly in humanities and gain little from the experience in spite of the Herculean efforts of humanities faculties. This is poignantly described by Professor Albert R. Gurney in his novel, *Entertaining Strangers*: "Over the years, we had worked out a kind of gentlemen's agreement together: I'd try to make the subject entertaining, they'd try to stay awake; I'd try to keep the assignments manageable, they'd try to do half of them; I'd be generous-spirited in correcting their papers, they'd hand something in when their schedule allowed."

Because systems engineers will spend their careers in nontechnical environments, they must learn to function in such milieus, and engineering educators quite properly hold to the humanities requirements. As an alternative, students could be allowed to pursue scientific and engineering subjects full time for their first three years. Then, when they become satiated with technology and also have matured in their appreciation of the relevance of the social sciences, they could devote their entire last year to the humanities. Obviously, this suggestion would be inappropriate for subjects involving several semesters such as foreign languages. Nevertheless, there is sufficient potential for improved benefit to students and increased morale of the humanities faculty to warrant trial of such a program.

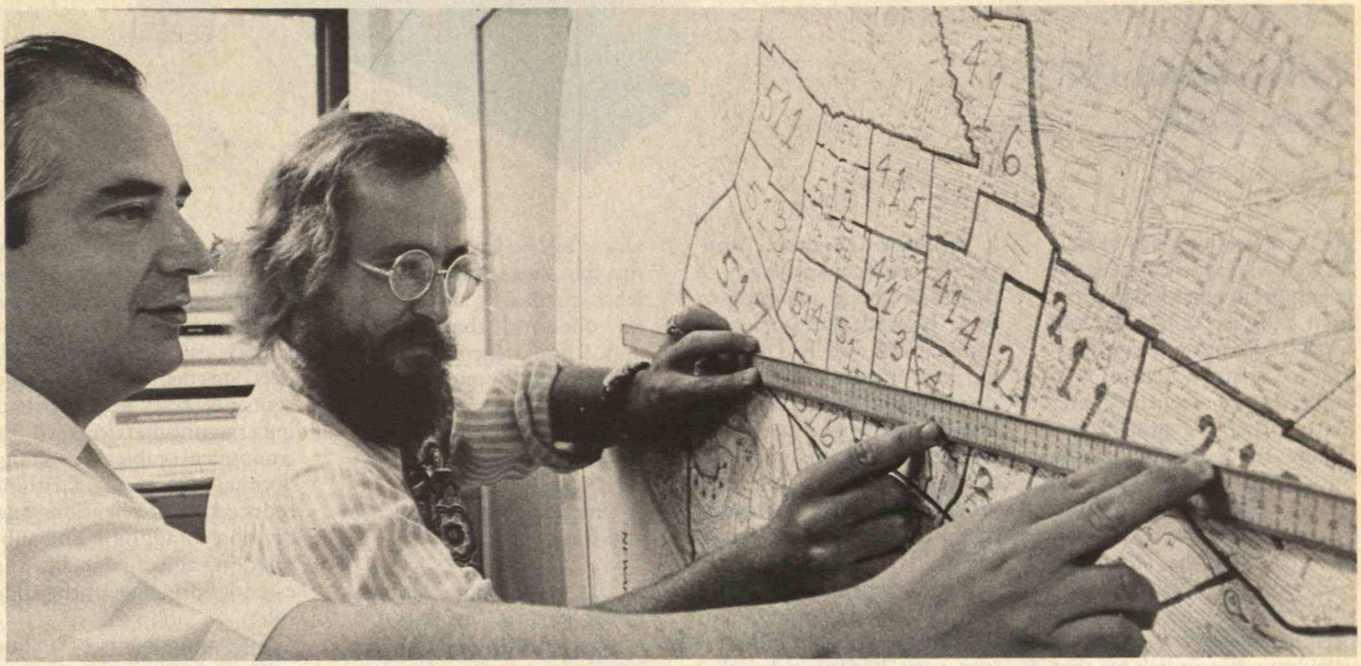
The old "3/2 plan" at M.I.T. was a variation of this scheme involving cooperation with liberal-arts colleges lacking engineering programs. Students at the liberal-arts college studied for three years to gain a science and humanities base and then came to M.I.T. for two years of intensive engineering education. They received a bachelor-of-arts degree from their liberal-arts college and a bachelor-of-science degree from M.I.T. In a reversal of this program, students interested in systems engineering could spend three years pursuing engineering subjects and then two years at a liberal-arts institution acquiring grounding in humanities and social sciences.

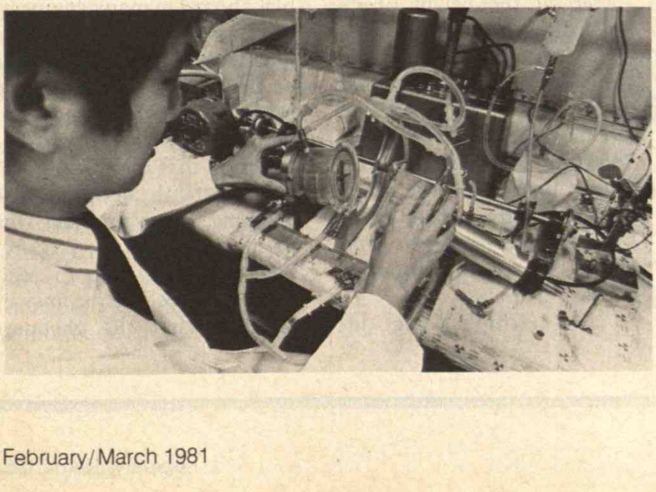
The Sloan Foundation has provided major funding to a number of schools to develop graduate programs for the systems engineer that are the forerunners of a trend toward programs at the various technology-society interfaces. Degrees could be given for studies of the interaction of technology with law, public policy, ethics, journalism, governance, and management. In an environment where engineering faculty members are already overwhelmed with keeping up with their own specialties, creating new knowledge through research, dealing with burgeoning enrollments, and attempting to improve engineering curricula, it is difficult to justify this dilution of resources. Nevertheless, the need for engineers qualified to interact broadly with society is urgent. The challenge is to create an organizational structure that maintains links with engineering departments and prevents proliferation of small, subcritical programs.

A Deeper Awareness of Technology

Another challenge to engineering educators is the education of nonengineers. As engineering education builds upon a base of science, so the society at large builds and feeds upon the work of the engineering profession.

Today, liberal-arts students are generally presumed to be unsatisfactorily educated unless they have some understanding of the nature of the universe they live in. A recent study of the core curriculum at Harvard University suggested that students should become acquainted with "basic principles of the physical, biological, and behavioral sciences and with science as a way of looking at [people] and the world." Given that the development of science into technology has an enormous impact on contemporary life, educated people should likewise have some understanding of the process by which science becomes technology and of the attitudes of the engineering profession. Therefore, an enormously important and challenging problem is to develop the means by which liberal-arts students can acquire a deeper awareness of the technology that so profoundly influences their lives. Perhaps this is the greatest challenge facing educators today.





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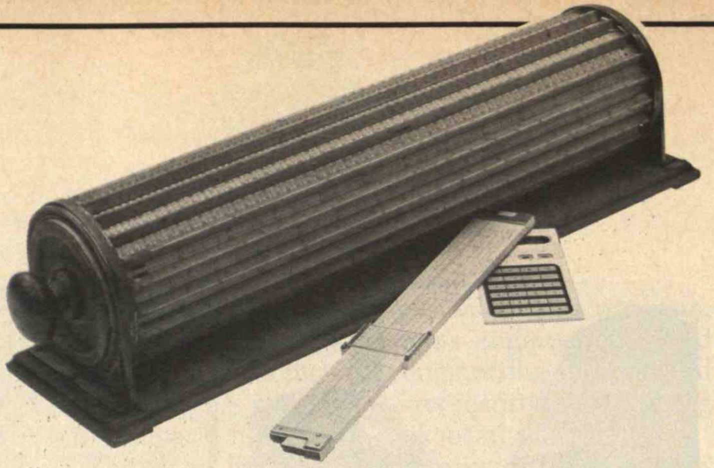

Reflections on a Slide Rule

by Henry Petroski

Computation pads of pale green quadrille paper are to engineers what long yellow legal pads are to lawyers and small white prescription pads are to doctors. There is a familiarity of size, color, and texture that the practitioner comes to feel comfortable with, and writing professionally on anything else can be distracting. Yet today I am distracted by the engineers' pad, for the once-familiar slide rule on the cover has been replaced by a pocket calculator, reminding me that engineering calculations aren't what they used to be.

From my earliest days in engineering school, I became as accustomed to seeing that slide rule as to reading the manufacturer's claims on each fresh pad I used. The pad was advertised as being "Lithographed for True Engineering Accuracy" with "Nonsmear Ink," so the lines would not be smudged by perspiration. Although I do recall striving for accuracy while sweating through final exams one hot May some 20 years ago, I cannot recall the degree of my accuracy or whether the ink on my computations smeared.

One thing that I do remember vividly is that after an engineering student's sweaty palm, the object most likely to be in contact with a computation pad was a ten-inch slide rule, if it was not hanging in its scabbard from the student's belt. Our professors told us that a good rule would last us throughout our careers, and the choice of a professional-grade "slipstick" preoccupied many a freshman for a semester or two. By the time we were sophomores, we had chosen our instruments according to their feel and special features. It was unlikely that civil, electrical, and mechanical engineers could comprehend, no less use, all the esoteric scales on one another's slide rules.

A wooden model made by the Post Co. gained popularity during the late fifties. I was very happy with other Post drafting instruments I had brought with me from high school, but the rule felt light in my hand and its case was an unattractive dark brown and bulky. There were also metal, plastic, and even circular models made by such companies as Dietzgen and Pickett, but these were generally preferred by eccentric or nonconformist engineering students. Neither my eccentricity nor my nonconformity expressed itself in my choice of slide rule, however, and I wanted none of the warping, binding, or cracking problems rumored to accompany some of the less popular designs.

The slide rule I did choose was the very popular and versatile Keuffel & Esser Log-Log Duplex Decitrig model, which came with a thin and attractive tan case that I did not choose to equip for belt-hanging. I was always very happy with my choice and always believed that the slide rule on the front of the engineers' computation pads was a K&E. I paid over $20 for the slide rule at a time when textbooks were selling for one-third that amount, and I took special care of what would be my most valuable possession until I bought a secondhand stereo in graduate school.

A Unique Symbol of Science and Engineering

It was that silent computational partner, my constant companion throughout college and my early engineering career, that came to mind as I took my present computation pad from the supply cabinet. For in place of the familiar slide rule, forever cocked to multiply 1.285 by something, is a stylized pocket electronic calculator displaying the number 42583.21, which is far too many digits for any ten-inch slide rule. Furthermore, the ubiquitous silicon-chip machine calls to mind the checkbook balancer and the supermarket shopper equally with the engineer: it is in no way uniquely a symbol of science or engineering the way the slide rule was for so long.

Even at the height of its popularity, the slide rule was a scientific curiosity in the hands of the uninitiated. To use a slide rule properly, one had to understand the principles of logarithms, those powers of ten and the interminable natural constant $e = 2.71828$ that scientists and engineers learn to manipulate as easily as pi.

Logarithms were developed in the early seventeenth century by John Napier, a Scot, to reduce the occurrence of errors in the tedious calculations of products, quotients, powers, and roots necessary for constructing trigonometric and astronomical tables to many decimal places. Logarithms reduced multiplication and division to addition and subtraction, and therein lies the essential principle of the slide rule.

The components of a slide rule are accurately marked not in equal divisions but in divisions proportional to the logarithms of the numbers inscribed on the scales. As the scales slide against one another, the logarithms of the numbers being multiplied or divided are added or subtracted as easily as one measures a line with a ruler. There is a certain skill to interpolating accurately between markings and to adding the proper numbers of zeroes or inserting the decimal point correctly in the answer. We learned this facility early freshman year using the six-foot working replica of a slide rule that hung over the blackboard in many engineering classrooms.

Although the whole class of neophytes was given the identical two numbers to multiply or divide, it was understood that they would not get identical answers. For example, if the problem was to multiply 132 by 783, no one would be able to read from the slide rule the answer 103,356 that the cheapest

Left: Three eras of calculators. The largest is "Thacher's calculating instrument," patented in 1881, which reads to five decimal places. The other two are the familiar traditional slide rule and the ubiquitous modern electronic calculator. *(Photo: Bruno Joachim for the M.I.T. Museum)*

Below: This engraved ivory pocket-sized calculator made in 1625 provides five major functions. The instrument tells time at various latitudes, determines magnetic north and true north, calculates time at night, determines wind direction, and calculates the date of Easter. *(Photo: John T. Hill, American Bureau of Shipping)*

calculator will display today. Instead, depending upon the precision of the slide rule and the skill of the user, the class reported answers ranging from 103,200 to 103,600. No one was expected to get much closer than 103,400, and the fourth digit (the 4) was only discernable because the computation involved the finer divisions at the left end of the rule. Students soon learned to report the "answer" as 103,000, said to have three significant digits because the result of a calculation cannot have more significant digits than the numbers from which it was obtained (132 and 783, in this case).

Sacrificing Reflection for Accuracy

Such exercises in humility and the limitations of the human brain, hand, and eye taught generations of engineers the folly of perfection. They knew from their earliest years that 103,356 square inches of carpet would cover an area 132 inches by 783 inches only if those were its exact dimensions. If the shorter dimension were in error by as little as one-tenth of an inch, one would need a carpet of 103,434+ square inches.

The limitations of the slide rule were also its strengths. The absence of a decimal point meant that the engineer always had to make a quick mental calculation independent of the calculating instrument to establish whether the job required 2.35, 23.5 or 235 yards of concrete. In this way, engineers learned early an intuitive appreciation of magnitudes.

Now the decimal point floats across the display of an electronic slide rule among extended digits that are too often copied down without thought. Whether the batteries of the calculator are low or the voltage high is seldom considered, and one-tenth or ten times the necessary concrete could easily be ordered without anyone being the wiser until the field engineer called for more concrete or for help. Of course, there are other means of checking calculations, but it is unfortunate to have lost one of the most reliable — reflection. □

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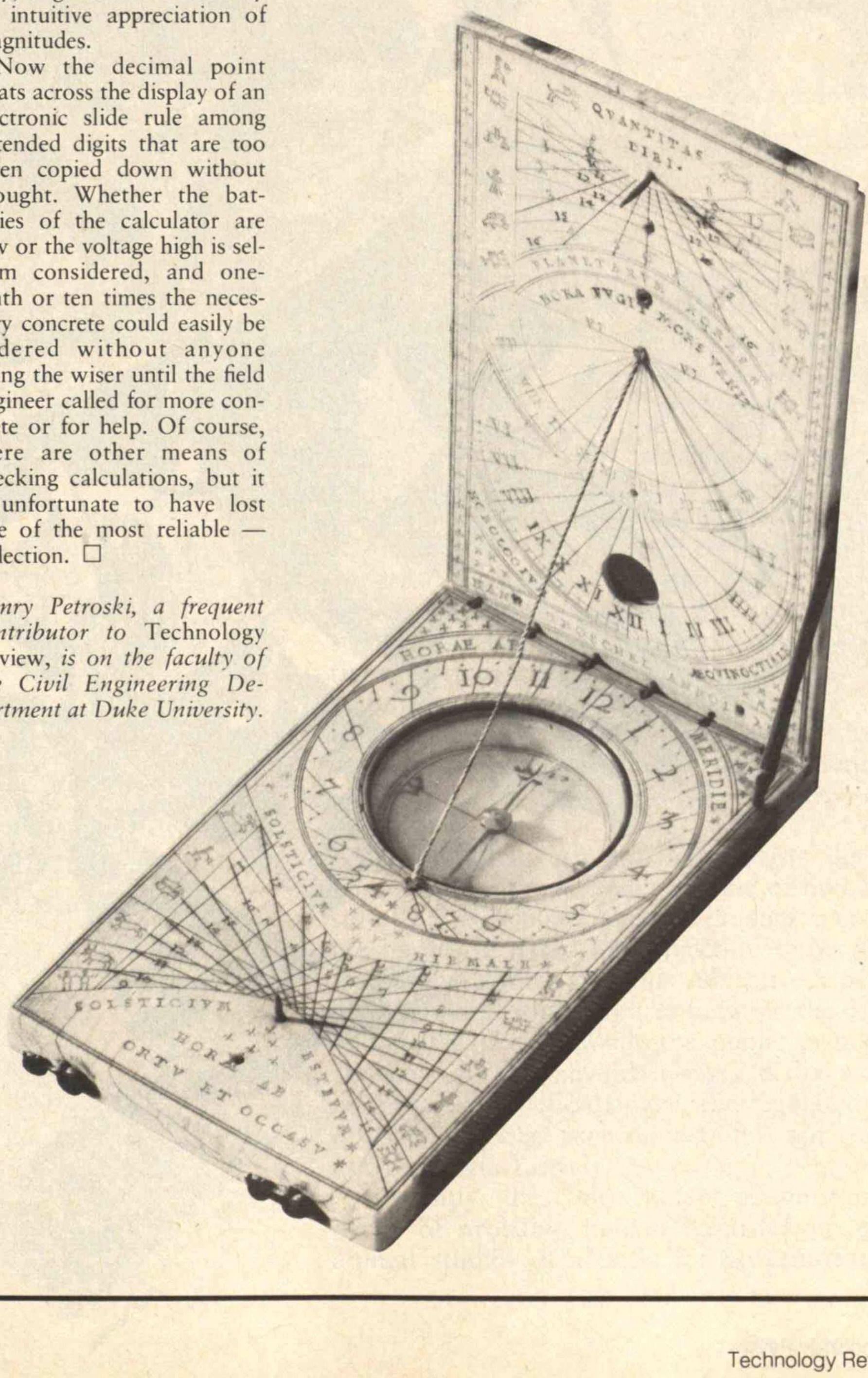

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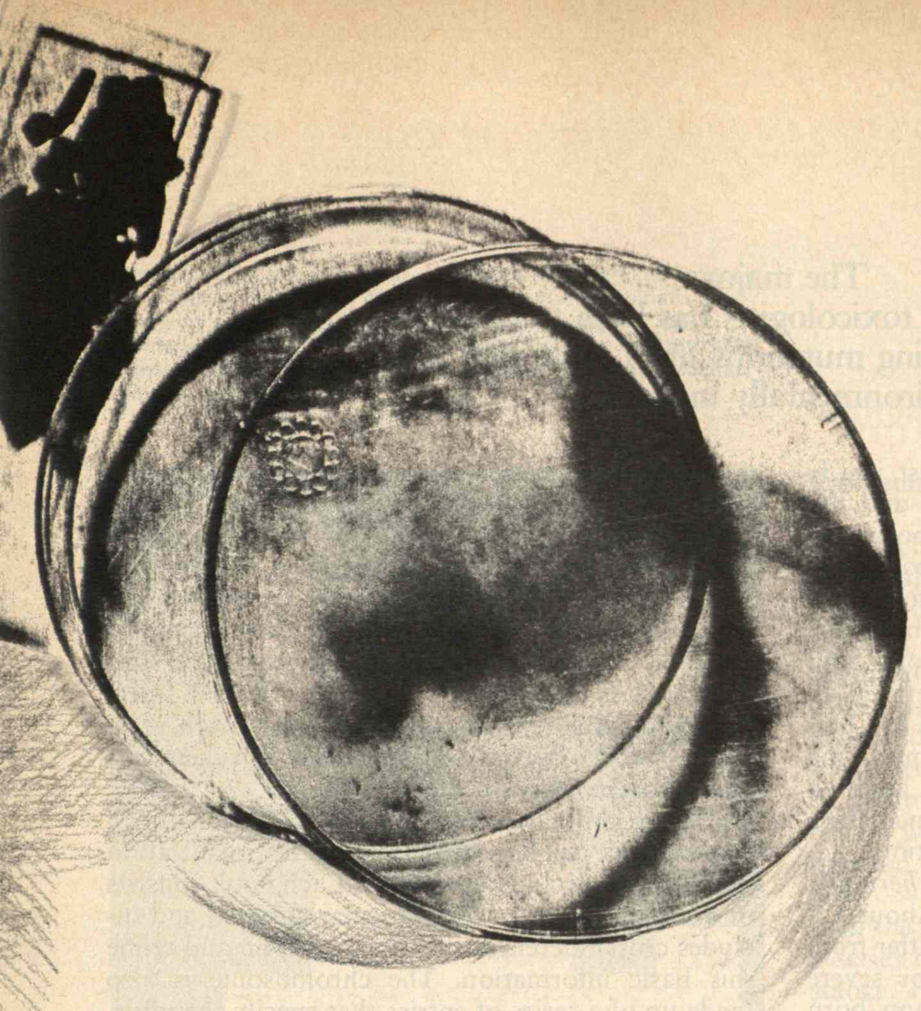


Chemicals, Genetic Damage, and the Search for Truth

by William G. Thilly

A method of determining which factors actually disrupt human genetic makeup is sorely needed to assure effective regulation of potentially harmful substances.

The regulation of chemicals suspected of posing a public health hazard is predicated on the sovereign right of the government to protect its citizens. No reasonable person would challenge the idea that citizens must not be unwittingly exposed to circumstances that lead to cancer, reduced fertility, defective offspring, and any of a myriad of other disabling conditions. But because so many Americans make a living from the manufacture, use, and distribution of chemicals, it is only natural that we require justification of any restrictions on otherwise useful substances.

Unfortunately, genetic toxicologists do not yet know how to predict the outcome of human exposure to a particular chemical. Predictions of probable harm are based on conjecture rather than demonstrable effects, and this subjective aspect is the primary cause of differences between the regulators and the regulated. While the public protector can choose to act when evidence suggests that a chemical might cause genetic damage, the regulated can oppose this because such damage has not been demonstrated conclusively.

Currently, the courts accept circumstantial evidence of probable human hazard from extensive animal studies as a basis for governmental regu-

The major problem of genetic toxicologists has been to distinguish naturally occurring mutations from those that are environmentally induced.

latory action. However, the evidence must justify both the qualitative decision to regulate and the quantitative decision to restrict human exposure.

This and other scientific uncertainty accompanying regulatory decision making has prompted a decade of research seeking more accurate means to discriminate between potentially hazardous and nonhazardous substances. The great biochemical diversity among humans and among species has prevented us from doing much more than improving our precision in the laboratory while we labor in profound ignorance of whether we are increasing the body of data relevant to human conditions.

There is no such uncertainty regarding *heritable* diseases of demonstrable genetic origin. About 1.7 percent of newborns in the United States suffer from serious genetic error leading to mental or severe physical impairment. Of the 3 million infants born in this country each year, some 50 thousand suffer some form of genetic abnormality — approximately the number of persons killed annually in automobile accidents. Our problem, in terms of current experimental practice, is to determine which chemicals could cause genetic change in humans. Genetic damage is alleged to lead to a host of human ills, including cancer, atherosclerosis, and premature aging. However, the accuracy of this hypothesis has never been rigorously demonstrated, and existing evidence is not wholly consistent with this conclusion. To fully understand the way this problem is approached, some knowledge of genetics is helpful.

Sources of Error

Reduced to its simplest elements, genetics is really a matter of information transfer, a transfer that can be interrupted in a number of ways. In fact, human genetic diseases arise from the failure of at least three separate modes of information transmission. Consider the analogy of an encyclopedia, which contains large amounts of information in a relatively small package. Every volume, page, and sentence must be passed on in its entirety and proper order if the information is to be transferred accurately; a missing volume, a torn page, or a scrambled sentence will interfere with this process. Each type of error is analogous to a category of genetic anomaly.

The large amount of information necessary to create a human being is packaged in 46 chromosomes. People who inherit more or fewer chromosomes suffer a variety of ill effects, the best known of which is Down's syndrome, or mongolism. This general class of genetic error, which effects 0.3 percent of all children born in this country each year, can be induced by exposing cells to certain chemicals (such as plant-derived alkaloids).

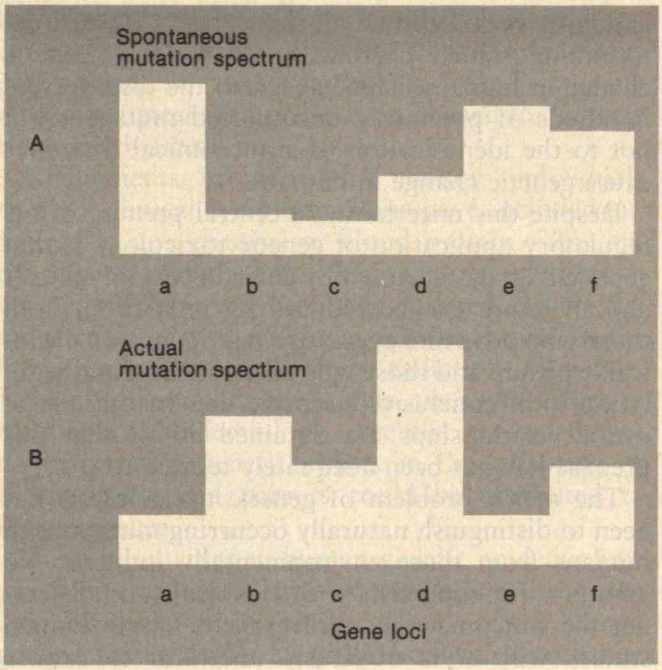
The organization of information *within* a chromosome can be compared with the organization of a single encyclopedia volume. Each book consists of a series of entries on particular subjects and includes cross-references that expand upon and refine this basic information. The chromosome is also made up of a series of entries that specify the information necessary to make particular structures. These relatively discrete information packages are called genes.

A broken chromosome is like a volume of an encyclopedia with half its pages ripped out — biologically, missing information usually spells disaster. Diseases caused by this second type of genetic error are relatively rare, occurring with each illness in only 1 to 10 of every 10,000 births. However, more than 700 individual diseases affecting 4 in every 1,000 children are associated with broken chromosomes, a problem of obvious significance.

Many kinds of chemicals have been shown to break chromosomes in human cells grown in the laboratory. Possibly the best-known agent is caffeine, but compounds in automobile exhausts, x-rays, and sunlight also have this effect.

The meaning of each entry in an encyclopedia volume depends on the precise order of the words in that volume — changing a few words here or there can render the information nonsensical. This can also happen with genetic information because a gene is just a linear sequence of four different units, or four "letters," that can specify up to 64 "words." These gene "words" are a code for making proteins that, when assembled, constitute the structures and functional units of a cell. If a word is changed or de-

Illustration of a possible result of measuring the number of mutations produced (A) spontaneously and (B) found to exist in actual human blood samples. Mutations that appear in spectrum B but not in spectrum A arose non-spontaneously and are indicative of an environmental influence on genetic makeup.



leted, a protein may also be changed so that it no longer carrries out its function. As a result, a cell may not be able to grow, function, or reproduce. Individuals born with a small genetic flaw may develop a number of serious disorders. About one in a hundred children are born with this kind of genetic error, a deviation of only one or a few of the letters of the genetic code within a single gene. These "gene-locus mutations" can be induced in human cells by a wide variety of chemicals, x-rays, and ultraviolet light.

Chemicals known to cause one kind of genetic error do not necessarily cause other kinds of genetic error. Vincalkaloids, used in cancer chemotherapy, cause errors in chromosome number but do not break chromosomes or cause gene mutations. Caffeine breaks human chromosomes but does not cause errors in chromosome number or within genes. At least two classes of chemicals, substituted acridines and nucleic-acid-base analogs, are known to cause only mutations within genes. Testing of the effect of a substance on human genetic makeup should involve the three kinds of genetic damage.

Problems Inherited or Acquired?

We can now consider those biological processes that might affect the appearance of genetic disease in people. First, potential victims must be exposed. That is, a person must absorb, inhale, or ingest a chemical, which must then be distributed to the part of the body where damage can occur. In the case of genetic disease, the targets are the germinal cells of the ovaries or testes. If other diseases, such as cancer or atherosclerosis, are of genetic origin, then other tissues would also be considered targets. Once distributed, the offending substance is absorbed by the cell.

In the majority of cases, cellular enzymes catalyze a series of reactions that detoxify most of the substance. However, in the process of detoxification, some reasonably stable but chemically reactive intermediates are formed. If these intermediates are generated in the vicinity of the genetic apparatus, they are often removed and the damage repaired by cell enzymes. But unrepaired or poorly repaired damage can result in either a chromosome break or an error in the sequence within a gene. Chemicals that cause errors in chromosome number don't seem to react with the actual genetic material but appear to interfere with chromosome distribution during cell division.

There are two schemes for testing the ability of a chemical to cause genetic damage. Small animals such as fruit flies or rodents can be used as surrogates for detecting genetic change in human offspring. Because genetic change is rare even in the presence of high concentrations of active chemicals, large numbers of animals are required. Facilities to test a significant number of chemicals this way would be prohibitively expensive, and therefore few studies of this kind take place. In the second scheme, single cells are used as surrogates for humans, a much less expensive procedure. Bacteria are typically used in these experiments, but many laboratories have developed the ability to use rodent or other mammalian cells, such as human white blood cells.

A modestly equipped laboratory can examine

Reduced to its simplest elements, genetics is really a matter of information transfer, a transfer that can be interrupted in a number of ways.

thousands of chemicals for their ability to cause mutations in bacteria every year. However, a serious drawback is that bacterial genetic material is packaged differently from that in humans — there is no opportunity to observe errors involving chromosome number or structure. An advantage is that well-performed studies using bacteria cost about $500 per compound. Studies of all three kinds of genetic change in mammalian cells cost about $5,000, involving tedious and demanding microscopic examinations of hundreds of cells per test.

Of course, there are important differences between the way that people appear to be exposed to chemical mutagens and the way that most tests of mutagenic potential are performed. People encounter a great variety of chemicals in amounts that rarely raise concentrations in body fluids above low levels. However, these concentrations of common chemicals may be maintained throughout a lifetime. Most laboratory studies involve exposing cells or animals to relatively large concentrations of chemicals for very short periods of time, and conclusions from these therefore might not to apply to humans. For instance, the liver's ability to detoxify foreign substances can be overwhelmed by very high concentrations of chemicals, as can that of other biological defense mechanisms.

Regardless of the type of cells used, genetic investigations have repeatedly demonstrated that the human environment contains many very potent mutagenic chemicals. That there is an associated public health problem is irrefutable: one need only visit our major pediatric hospitals in which some 40 to 50 percent of inpatient time is now devoted to children with birth defects to confirm this. However, whether environmental mutagens actually *cause* the diseases remains unclear.

Here, then, is the essence of the controversy. Well-meaning persons hoping to reduce the frequency of genetic disease advocate removal of mutagens from the environment. Persons whose livelihood might be eliminated along with any particular mutagen argue that the weight of scientific evidence is insufficient to establish a cause-and-effect relationship. In the last decade, genetic toxicologists have devoted all their efforts toward determining which chemicals *could* cause genetic change in humans. This has led to the discovery of hundreds of previously unsuspected mutagens but not to the identification of any chemical that does cause genetic change in humans.

Despite this uncertainty, a central premise of the regulatory application of genetic toxicology is that genetic damage *is* caused by enviromental chemicals and therefore can be reduced by regulation. Both those who advocate aggressive restrictions on chemical exposure and those who advocate minimal regulation until conclusive scientific demonstrations of causal relationships are obtained admit that this premise has not been adequately tested.

The major problem of genetic toxicologists has been to distinguish naturally occurring mutations in humans from those environmentally induced. No amount of mixing cells with chemicals and observing the outcome will resolve this — only human studies will. It is obviously unethical to expose people to massive doses of possible mutagens to obtain this information, and this has prevented scientists from making absolute determinations. This, in turn, has typically prompted a public cry for epidemiological studies to determine whether genetic damage in the offspring of persons exposed to high levels of mutagens is significantly associated with the damage to their parents' genes. So far, this question has been difficult to answer conclusively because the number of people regularly exposed to demonstrably high quantities of mutagens is small, and the number of children born after such exposure is even smaller.

If we use 2 percent as the average frequency of all heritable disease in the United States, even if we locate 100 offspring of persons exposed to mutagens that doubled their probability of genetic change, we would expect only 4 instead of 2 affected children in the exposed group. For a doubling of genetic disease to be statistically significant, one would have to observe a minimum of 16 afflicted individuals in a random sample in which only 8 were expected among 400 newborns. Thus, only in a special situation where many persons were exposed to the *same*

A broken chromosome is like a volume of an encyclopedia with half its pages ripped out — missing information usually spells biological disaster.

highly mutagenic conditions could an epidemiological survey reveal useful results. Indeed, the inherently imprecise decision making based on such epidemiological studies has been likened to "cutting butter with a balloon."

Refinements in identifying mutant individuals through clinical symptoms alone have included examination for changes in blood protein. This approach was applied to the Japanese victims of atomic warfare, a group that suffered clearly demonstrable carcinogenic damage (leukemia) in the first decade after exposure to radiation. However, James Neel, the leader of this awesome effort in biochemical epidemiology, recently concluded that no discernable genetic effects in the offspring of radiation-exposed parents could be attributed to that exposure.

Present activities in human genetic epidemiology are bound to yield equivocal results because of the inherent variation in specific sections of the human genetic material. We all differ from one another in an absolute genetic sense; turning again to the encyclopedic analogy, we see that some of us have entries that convey the same essential information but in phraseology slightly different from the norm. Thus, because changes on a genetic level have accumulated for millenia, it is not generally possible to tell which changes arose in a parent or an ancestor. This genetic "heteromorphism" makes resolution of the central problems of genetic toxicology, using population studies and present strategies, appear unlikely.

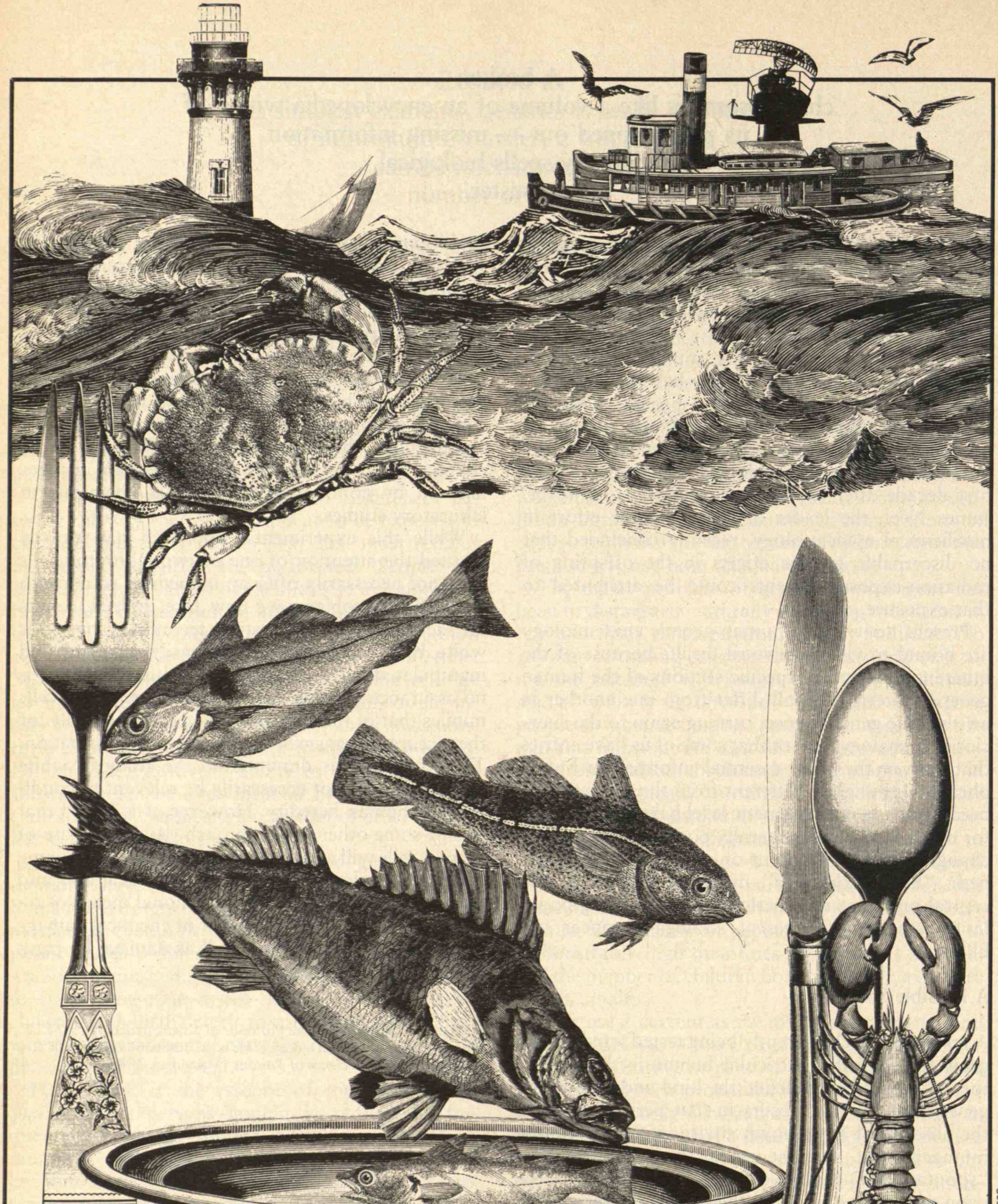
A Possible Solution

A novel approach currently being tested would be to grow the cells of a particular human in the laboratory. We could then define the kind and amount of genetic change that occurs in *that* person's cells in the absence of any known environmental chemical mutagen. The scientist could then compare this "spontaneous" genetic damage to the actual spectrum of genetic damage in the cells of the same individual. Based on what we know about spontaneous and chemically induced changes in human cells, we could expect to discover whether that person had suffered any significant, nonspontaneous — environmentally mediated — genetic change during his or her lifetime.

The validity of this hypothesis is now being tested by myself and by Thomas Skopek at Yale University. If tests show that the spectrum of genetic change in a person's white blood cells is different from the spectrum of spontaneous genetic change, we may be able to diagnose the mutagen responsible for those changes and compare them to the spectrum changes induced by common environmental chemicals in laboratory studies.

While this experimental approach has already merited the attention of one or two laboratories, it does not necessarily offer an immediate solution to the difficult problems we now face. Indeed, results are achievable with existing techniques *only* for white blood cells, which are easily sampled and manipulated in the laboratory. For instance, there is no assurance that the behavior of white blood cells mimics that of the human germ cells responsible for the accurate transmission of genetic information. Thus, conclusions drawn from the study of white blood cells will not necessarily be relevant to conditions of human heredity. However, it is hoped that this or some other new approach that makes use of human cells will stimulate research aimed at moving genetic toxicology out of the hypothetical and into the actual. We must develop a rational means of resolving the deep and logical fear of chemical damage to our genetic integrity, as well as damage by regulation to our economic stability.

William G. Thilly is associate professor of genetic toxicology at M.I.T., where he received his Sc.D. degree. He is the author of a chapter in *Toxicology: The Basic Science of Poisons* (Macmillan, 1980).



Karen Watson

World Fisheries in the Twenty-First Century

by
R.L. Edwards
and J.B. Suomala, Jr.

The world fishing industry is turning toward novel technologies — both higher and lower — to meet new challenges and constraints at sea and in the marketplace.

During the final years of this century, the ocean fishing industry will make pragmatic and almost desperate attempts to deal with two major constraints: the 200-mile economic zones that many countries have adopted to protect their resources from overfishing, and facilities and vessels that are growing obsolete though not yet fully amortized. At first, high-technology aids will be called on to improve efficiency of operation. Then, a transition from active to passive fishing techniques will occur: nets — trawls and seines — will give way to extensive systems of weirs, stationary nets anchored to the sea bottom that corral and trap fish. These countertrends toward and away from more technology are likely to continue far into the next century.

For the past 20 years, we have seen rapid growth in the size of the catch, the building of large fishing fleets capable of operating in distant waters, and the exploitation of nearly all the best marine fishing grounds. But the sizes of fish harvests are leveling off, and there is growing appreciation of the consequences of overzealous exploitation.

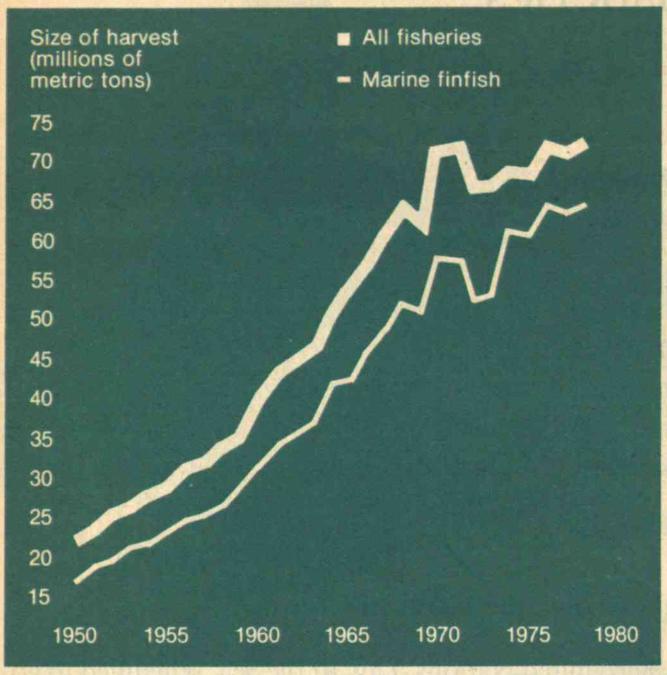
In 1961, the global yield of traditional marine bony fish was estimated to be somewhere between 55 and 60 million metric tons per year. World landings today are still in that range — about 57 million metric tons in 1979 — and cannot rise much above that level on an extended basis without serious depletion of the resource. We estimate that the catch of conventional bony fish in the year 2000 will be between 70 and 80 million metric tons, with the bulk coming from continental shelf areas as it does today.

Extending the Limits to Growth

The United Nations' Law of the Sea, scheduled to go to member states for ratification next year, is likely to affect the size of the catch by mandating 12-mile territorial boundaries and 200-mile "exclusive economic zones" for coastal nations. These nations will control marine resources within their 200-mile limits and above continental shelves (if any exist) beyond that limit. Other nations that will be constrained by these provisions have begun research on potential fishing resources in areas outside the 200-mile zone, which are expected to remain under international jurisdiction.

One such research activity is aimed at determining the usefulness of such unconventional organisms as krill and lanternfish to help meet protein needs. These smaller organisms, particularly the invertebrates, are quite abundant, and could bring the annual potential for marine fish landings in 1981 to hundreds of millions of metric tons. But realization of this increased harvest is by no means certain.

Fortunately, most ocean animals aggregate to one degree or another. Bony fish may have commercial potential even in average densities of fewer than one fish for each cubic meter of water, and a good fishing trawler may average 50 tons of bony fish in 24 hours of fishing in waters above the continental shelf. Though the density of smaller organisms can be much greater, each organism weighs very little, and a well-equipped trawler may capture only about 1 ton of invertebrates per day — clearly an uneconom-



Graph showing the changes in total fishery and marine finfish harvests for 1950 to 1978. Note that the sizes of the harvests started to decline in the late 1960s. World landings cannot rise much above current levels without serious depletion of the resource. Thus, investment in sophisticated electronic aids for the fishing fleet will have to be balanced against diminishing returns in the next several decades. (*Data: United Nations Food and Agriculture Organization*)

ical effort. The Antarctic krill *Euphasia superba*, which represents one of the largest protein "blocks" yet unexploited by the world fishing industry, is an exception: Japanese vessels have managed to average nearly 20 tons of krill per day. The extent and size of the biomass of krill are not precisely known, however, nor is it understood how changes in krill population could affect the great whale population (which feeds upon them) and the already beleaguered whaling industry.

The most crucial issue in selecting the catch is the amount of energy needed to land and process a given weight of protein. The harvesting and processing of fishing products generally require comparable, if not slightly smaller, expenditures of energy than most agricultural products.

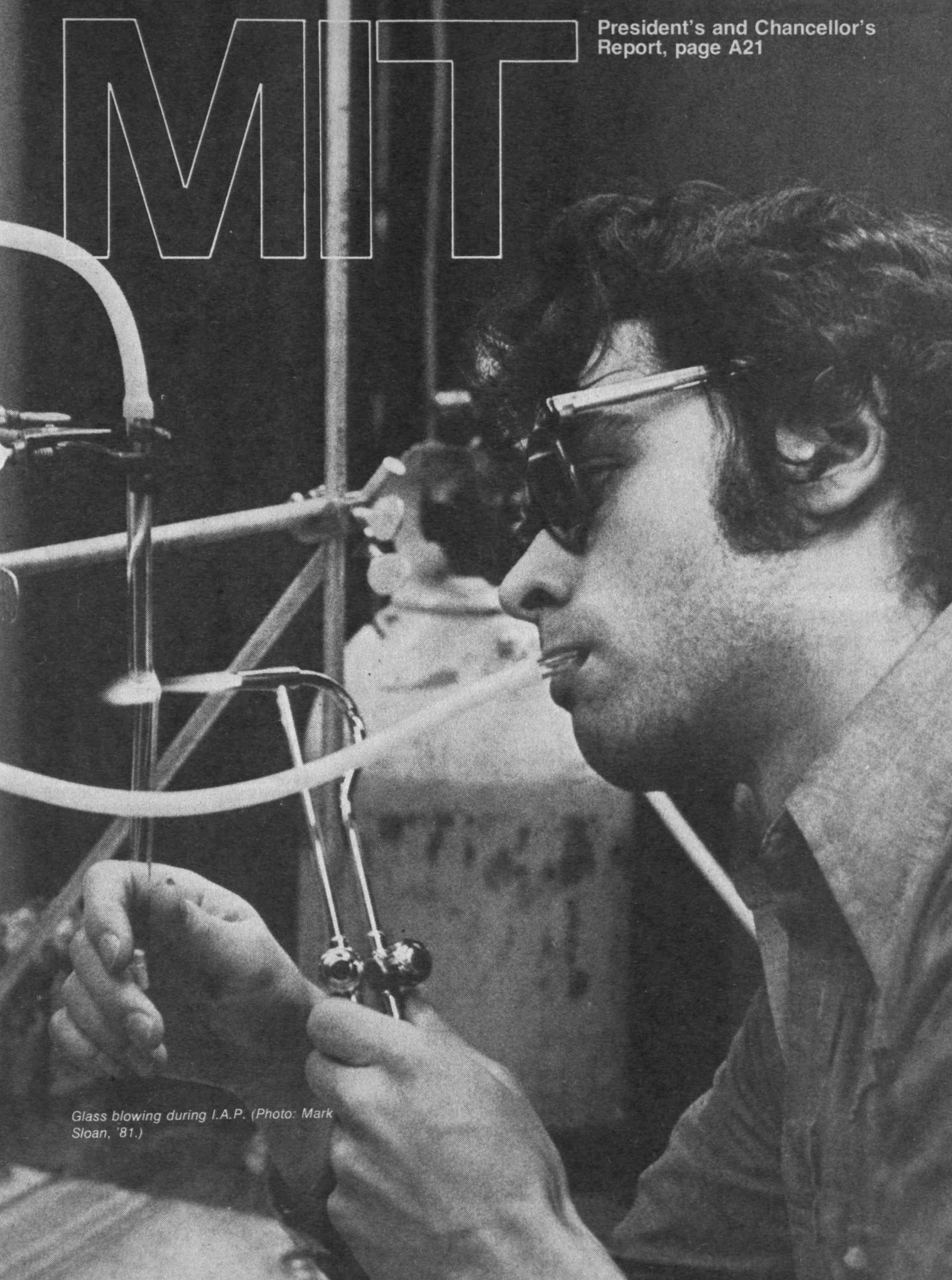
A large fraction of the energy embodied in a marine protein resource is expended in harvesting it. However, the relative amount of energy needed to capture different species varies substantially. For example, nearly 70 kilocalories of energy are needed to capture one gram of shrimp, but only 4 kilocalories are expended to capture one gram of bottom fish such as cod, flounder, and hake. (The energy expended to catch cod is approximately equal to the energy in its protein; the energy to catch shrimp is about 25 times greater than the energy in its protein.)

The ease of harvesting depends to a large extent on the relative density and habitat of the resource. For example, pelagic sardines and anchovies, which usually occur in schools, can easily be found and harvested with active netting gear. But lobster, which aggregate on the sea floor, are usually caught with relatively inefficient passive gear such as traps. The biomass of smaller planktonic organisms over large areas can be impressive, and these organisms reproduce very rapidly, some in a matter of days. However, they may aggregate (sometimes quite sparsely) within very small intervals of depth, typically at considerable distance from the sea surface. As a result, the efficiency of fishing for such organisms tends to be very low.

Likewise, the efficiency of fishing for very large organisms such as whales, tuna, and swordfish is low: although the protein is highly concentrated, it represents only a tiny fraction of the biomass of the world's oceans. These large creatures gather in areas hundreds of kilometers across, and fishing fleets must often travel thousands of miles and burn up

MIT

President's and Chancellor's
Report, page A21



Glass blowing during I.A.P. (Photo: Mark Sloan, '81.)

Drama: Gaining Understanding by Showing the Invisible

One-act plays, such as those on these pages, are an important part of the drama schedule. Professor Robert Scanlan, '70, director of the Drama Program, would like to see more of these one-act plays written by students. They are all directed, designed and constructed by students. The idea is to give students the full range of responsibility and experience, including the opportunity to make mistakes under supervision, explains Dr. Scanlan.

This page: The Police, *by Slawomir Mrozek, directed by Sarah Axel, '81. Actors, left to right: Alan Cohen, '82, Mark Troy, '83, Jim Leatham, '84. Opposite page, top: Joan Solomon, '80, in Arthur Kopit's* Chamber Music, *directed by David Waggett, '81. Bottom: Edythe Frampton, Wellesley, '80, and Kevin Cunningham, '82, in Tom Stoppard's* After Magritte, *directed by Joan Solomon. (Photos: Tom Bloom)*

To Robert Scanlan, '70, director of the M.I.T. Drama Program, science, engineering, and the dramatic arts have a lot in common. The growing success of Dramashop productions and his classes in drama seems to prove the point.

Dr. Scanlan is comfortable with the comparison between drama and technology; he has two undergraduate degrees from M.I.T. (in mechanical engineering and humanities) and a Ph.D. from Rutgers (in comparative literature with drama as his principal field). During some of those years he also worked as a stage manager and director at Harvard's Loeb Drama Center in Cambridge.

Now his role at M.I.T. is assistant professor of drama and theater arts. He divides his time equally between directing the drama program and teaching dramatic literature.

Though M.I.T. students are "radically different" from those found in a drama school, Professor Scanlan finds them "remarkably better, with no preconceptions, open-minded, creative, unpretentious, and enormously bright. It's a freeing environment in which to do the arts."

Professor Scanlan thinks his background explains his interest in the interface between technology and the arts. "I look at theater as a humanities laboratory — something analogous to an engineering laboratory in its relation to pure science," he says. Mathematical modeling is not so different from playwriting. I think both represent an effort of the mind to translate reality. The intention of mathematical modeling is to grasp manageable systems in a fundamental way. Playwriting begins with the same fundamental reality, the playwrite giving it an analogous form to carry it over to the audience. A brilliant mathematician's formula successfully modeling movement in space is much akin to a play that clearly depicts an aspect of human motivation. A great play grasps an essence and gives it form."

For performers, too, the links are strong. "People such as M.I.T. students who have already experienced the difference between theory and practice (in science) can focus even more, through performance, on literary meaning in drama. "You can test the knowledge you *think* you have — and may discover you are wrong. Then you go back and base your performance on knowledge that you *know* you have. It adds a new dimension."

"I'm building the idea of the performing arts program on that balance between theory and practice," says Professor Scanlan, and in that sense transferring science and engineering skills to theatre arts is not at all difficult.

The drama program puts on two full-length plays a year, using a six-week production period to prepare for performances given on two consecutive weekends, one in each term. The production period is the crucial part. "Performance is not our primary goal; it is the motivation for a teaching function," explains Dr. Scanlan.

During the year there are also three or four fully produced evenings of one-act

plays, directed, designed, and constructed entirely by students. The idea there is to give students the full range of responsibility and experience including the opportunity to make mistakes under supervision. We let them do even something we think will lead to disaster," says Professor Scanlan. "And the result is often that they show us new techniques."

Some of these one-act plays have been student-written, and Dr. Scanlan would like to see more one-act plays written by students. "My theory to generate good student plays," he says, "is to promise to perform the best available. Even if we start with poor plays, viewers will say 'I can do better' and produce a stronger script."

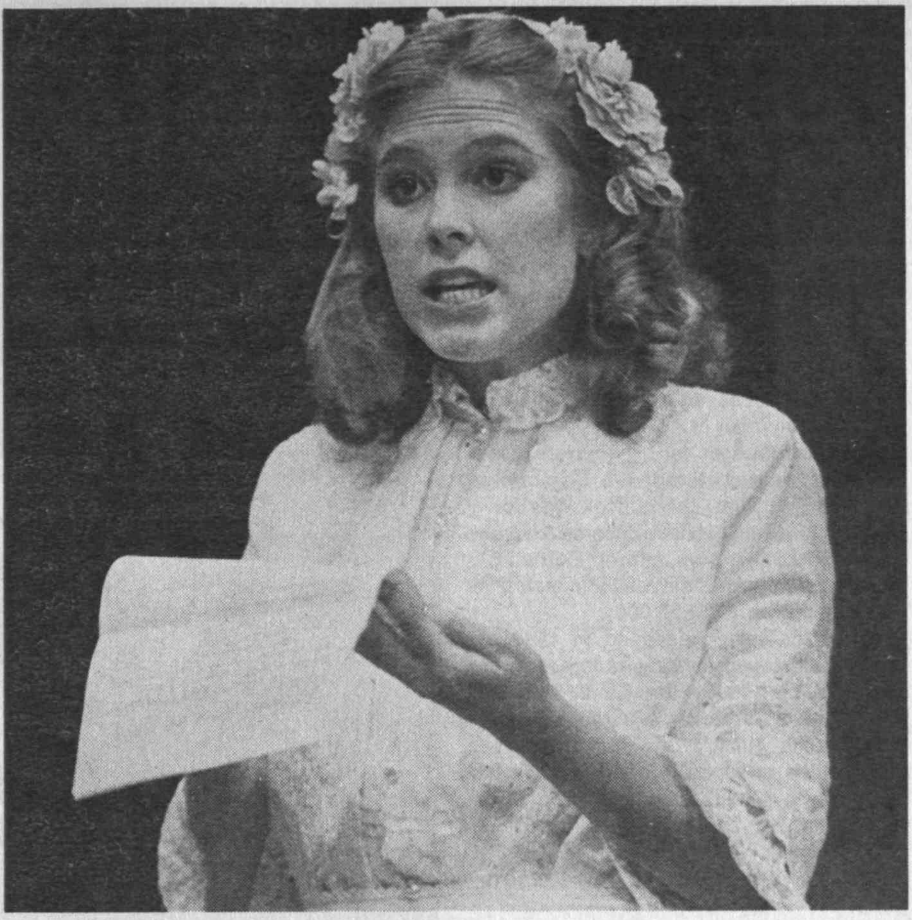
Actors are chosen through open casting in the M.I.T. community, but there is a priority: M.I.T. and Wellesley students first. For M.I.T. students, rehearsal time is a strain for the leads, who must budget their time carefully. I.A.P. is ideal; then rehersals do not compete with study time.

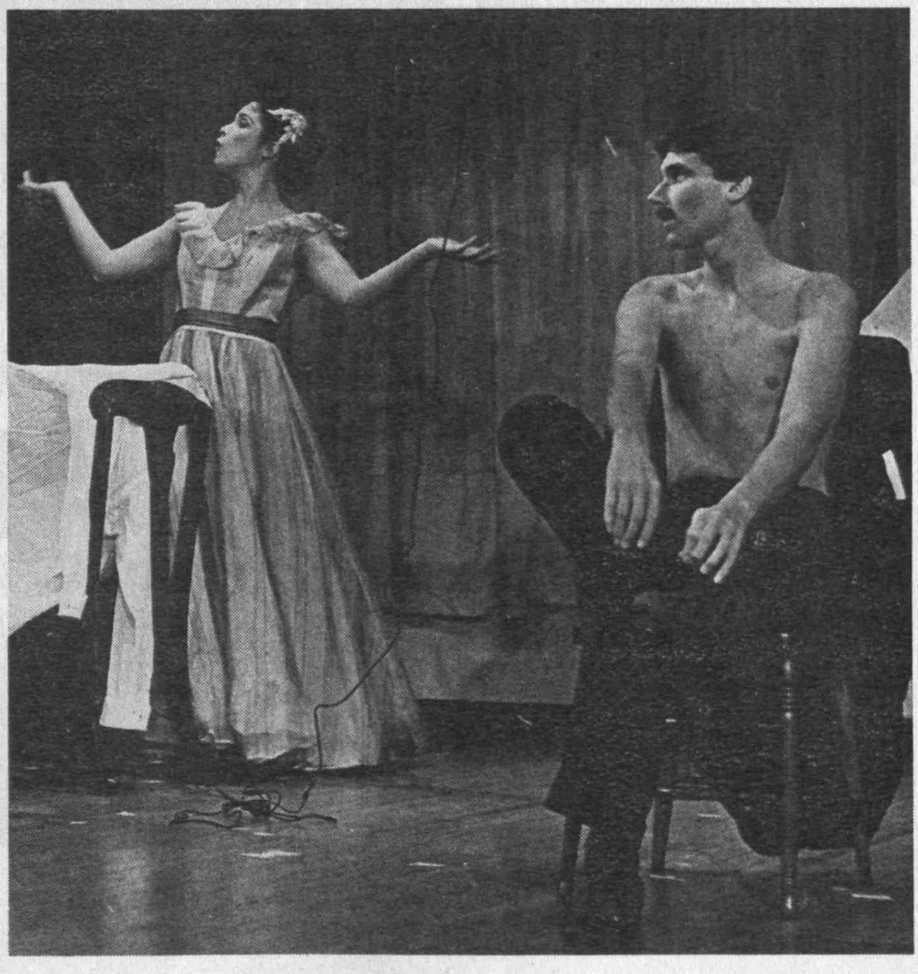
Another problem: facilities. "We're lacking in resources, space, and staff," he explains. The primary need is for space. Last year, with Kresge Auditorium closed, the American Repertory Theatre (which was installed at Harvard last year) gave the M.I.T. drama program the Loeb Theatre for *The Misanthrope*. "It was the grandest thing we did; it vindicated my confidence that if given the resources, we can rise to the occasion," Dr. Scanlan said. "We sold out at the Loeb, and it's a big space." Also needed: a more flexible production schedule. The present rigid schedule has to be prepared a year in advance because of competition for space in Kresge. This hampers interraction with other activities such as film/video and advanced visual studies. In all, Dr. Scanlan thinks that drama is the least developed of the arts at M.I.T., considering its potential.

Plays are generally picked from the established repertory of classical theatre. "I try to pick masterpieces, and I have a strong preference for serious drama," explains Dr. Scanlan. "Included in that are major comedies, but I'm not likely to do musicals. Entertainment is not the point.

"This is really an art theatre," says Professor Scanlan. "I consider the theatre as a cultural instrument of the highest subtlety — as art form, not entertainment. Good theatre is always entertainment; good entertainment is not always good theatre."

The values of drama to students? First, they acquire "deep psychological insights into how humans interract," answers Dr. Scanlan. "We're looking for the quality of humanism. Second, I think that I push them toward an awareness of how to shape an idea into concrete form — the essence of all art and also of science and engineering. I try to give them a full sense of the instrument we call a theater. Like a scanning electron microscope, a theater makes it possible to *see* something you wouldn't normally be able to see." — *M.L.*





Two Years of Balanced Budgets, but the Chronic Problem Unconquered

M.I.T.'s financial fortunes are a little like New England weather: "Wait a minute and it will change."

However true that statement may be for last year and this year, when financial results were unexpectedly better than early projections, it does not gainsay a continuing money problem for M.I.T.

When the budget for the current fiscal year first went to the M.I.T. Corporation almost a year ago, the outlook was for a $1.7 million gap between income and expenses. But now, says John A. Currie, '57, director of finance, the outlook is for "a modest surplus" of $500,000.

The same thing happened in 1979-80, when a $2 million deficit was forecast; the final result of the year was a $376,000 surplus — not including a number of unrestricted gifts which at the end of the year were added to capital. Notable among the latter was a $610,000 bequest from Oliver E. Conklin, '16, added to funds functioning as endowment — "the first such net addition from this source since 1972," Mr. Currie reports.

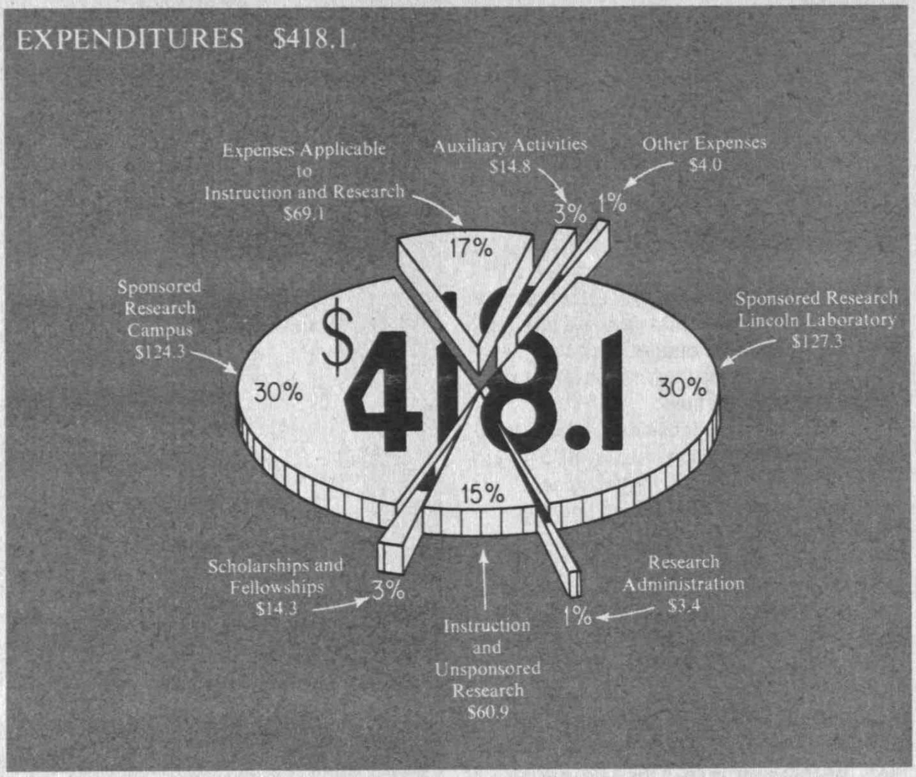
The better-than-expected performance last year was the result of a mild winter, the availability of low-priced natural gas, and unexpectedly large return on investment generated by high short-term money-market interest rates. The same high interest rates are helping this year; so is an unexpected increase in graduate enrollment, increasing research volume, and generous gift income.

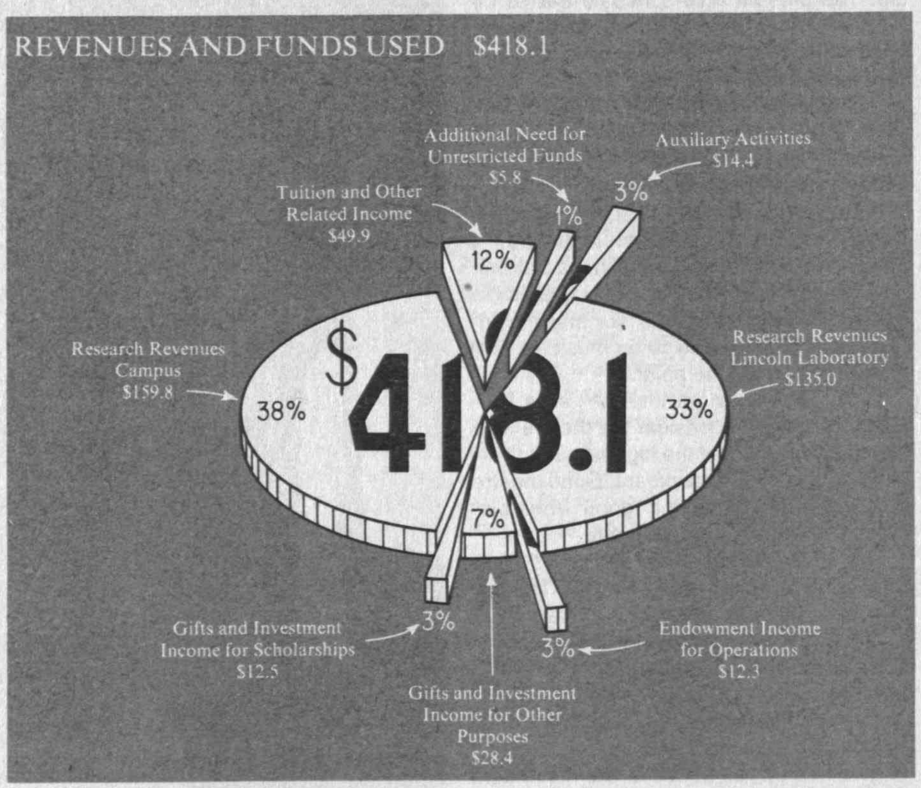
The records of 1979-80 and 1980-81 mean that M.I.T.'s income and outgo has been in balance for all of the last four fiscal years. Throughout this period, says Mr. Currie, the Institute has been helped "by the faithful stewardship of those academic and support departments who lived within their budgets."

The Inflation-Driven Chronic Imbalance

But Mr. Currie hastens to point out that the $500,000 surplus expected on June 30 is so small in relation to a total operation of $440 million — 0.1 percent — that "we must not relax our control on expenditures or sit back assuming that M.I.T. has solved its chronic problem of financial imbalance."

That chronic problem arises mostly in the failure of current gift and investment income to keep pace with inflation. President Paul E. Gray, '54, explained that dilemma to members of the M.I.T. Club of Southern California in response to a question late in the fall: "As long as these two facets of the university's income do not grow as fast as expenses, you have a built-in problem





M.I.T.'s outgo (left) and income in 1979-80. Though at one point the year was expected to show a deficit of as much as $2 million, several factors combined by the end of the year to make expenditures and revenue into almost precise balance – a surplus of $376,000 on total operations of over $418 million. "The vitality of the enterprise as it enters the 1980s is good," Stuart H. Cowen, vice-president for financial operations, and Glenn P. Strehle, '58, treasurer, wrote in their annual report to the M.I.T. Corporation last fall. "But the need for substantial outside support to maintain it has never been greater."

which can be described in these terms: next year if you do everything you did this year — same people, same programs, same activities in every respect — and if your budget was balanced this year, next year's will be out of balance. If you don't correct it that year," he said, "the following year's budget will be out of balance by twice as much. And the next year by three times as much."

The Institute's financial problem, said President Gray, is simply to respond to this chronic imbalance in ways that will not limit the range of activities needlessly or impinge on the quality of the university. It is a task, he said, which puts "particular emphasis on the need for gift support and creative management of invested funds."

To Mr. Currie that seems to mean three things:

☐ Continued emphasis on obtaining "that scarcest of resources," unrestricted funds. "For it is this resource that in the past has been available to underwrite promising new ventures, to provide support for young faculty and give them freedom to follow their interests and instincts wherever they may lead."

☐ Continued increases in tuition and room-and-board charges, keeping pace with inflation.

☐ Continuing emphasis on increasing M.I.T.'s capital base, to make the Institute less vulnerable to the "chronic financial imbalance" problem. Accordingly, Mr. Currie pledges "a continued high level of fund-raising from industry, foundations, and private donors." And, he says, the Institute will have to be prepared "to pare back programs where faculty or student interest is low, difficult though it may be, so that resources of money and space can be freed up for the new growth areas of the 1980s."

We cannot look far into the future. We cannot tell what buds of genius may be unfolded in these columns. But even if genius does not bloom; even if the beauties of rhetoric and poetry are not developed here; even if this paper becomes, like the school it represents, only a field for plain honest work — we shall nevertheless be sure that the efforts we make are stepping stones to further attainments, helping us all to the higher and nobler uses of our lives.

A noble purpose was proclaimed by the founding editors of The Tech *in November, 1881 (above). Fifty years later James R. Killian, Jr., '26, then editor of* The Tech, *waxed eloquent, too: "A student newspaper at the Institute is a symbol of our nation's great free press," he wrote. "It must maintain its objectivity within a framework of impressive responsibilities and opportunities."*

The Tech at 100: A Force to Match That of M.I.T.

The Tech, born on November 16, 1881, has now endured for a century as one of the most prestigious M.I.T. student activities. Approaching the 100-year milestone, three of today's editors — articulate and thoughtful, like all of their predecessors — agreed to talk with us about their service, their responsibilities, and the campus they serve.

Meet Stephanie Pollack, '82, chairman; Steven Solnick, '81, former editor-in-chief; and Richard Saltz, '82, who began his term as editor-in-chief just a month ago:

We have tried to promote more aggressive investigative reporting and a new interest in national affairs, they explained. At one time interest in national issues wiped out the relevance of *The Tech* as a student newspaper, and it has been flip-flopping between the two poles ever since. "Now, says Mr. Solnick, "the two are converging. Editorials, dropped a long time ago, have been reinstated. We intend to keep them up," he says. Stephanie Pollack: "We focus on events that have relevance at M.I.T.; to bring those national events into an M.I.T. context and bring M.I.T. events out." Rich Saltz: "M.I.T. is an influential force. But *The Tech* hasn't spoken up as much as it did in the past, due to a limited staff and time. We work a fine line with minimal resources. When we expand to cover national news, people become interested in that and forget the student voice of the paper."

Steve Solnick: "People who are students here — by the fact of going here — are involved in national issues. At least that's what we're trying to convince them. We try to make them realize that they can't say I'm just a student — that there are broader issues that confront students," he emphasized.

More Than a Student Activity

For the staff of *The Tech*, commitment to the paper is serious. "In the last year we made an attempt to change our internal image," explained Ms. Pollack. "We want to think of *The Tech* as more than a student activity —

a responsible job that requires a stronger commitment. One hundred years of *The Tech* sit in this room; it is an institution." And it spawned at least two other campus publications: *Technique*, the yearbook, born in 1885; and *Tech Engineering News*, a spin-off in 1919.

The Tech is different from any other acitivity, said Stephanie. "If a reporter makes an error, and we print something erroneous, a good number of the M.I.T. population read it. We look like fools, and the community is mislead.

Ms. Pollack thinks of the responsibility of the staff of *The Tech* as three-layered: first to the people who founded the newspaper; then to the community that reads *The Tech* on Tuesday and Friday; and finally the people who will read it in the future. Going through old volumes should give a reader an accurate picture of what M.I.T. was like. Mr. Saltz: "If someone wants to know the campus reaction to mandatory commons, for example, we must go on record as a student voice in print."

How has *The Tech* has been able to attract able, committed students for 100 continuous years? Because journalism is exciting — in fact, it is addicting — said the staff.

How did they get involved? Stephanie came to M.I.T. for Open House, wandered into *The Tech* office, and has been there ever since. Rich got involved in writing a humor column for his high school newspaper; there was no question of his joining *The Tech*. Steve bought a camera and was invited to work for *The Tech* — and quickly discovered that this was the way to get free film. Soon he was photo editor, found it compelling, started writing news, and switched to columns "because I wanted to do something for M.I.T., to make people stop and think where they are and what they're doing."

Students who "hang in there" as reporters and writers and eventually become members of the editorial staff, explained Stephanie, feel they are doing something worthwhile for the community. "I wouldn't be here till 3:00 a.m. if I didn't think I was doing something once in a while." Rich: "I missed an assignment because I was working at *The Tech*. When I explained, sheepishly, to the professor, he said the newspaper is the best it's been in 18 years; so just turn your assignment in real soon." Stephanie: "Someone who doesn't live in my dorm stops me and says, 'Hey, I liked your column.' But," she adds wistfully, "some of our serious articles don't get noticed.

Special projects are planned in honor of the centennial: a reception for alumni next fall; a lecture series during the fall term called "Journalists on Journalism"; an exhibit in the Compton Gallery on the history of M.I.T. activities as seen through *The Tech* (it will open on November 16, the exact 100th anniversary). The Sunday before that event will be a banquet, the culmination of a fund-raising effort for an index project.

The first front page, November 16, 1881.

A Power Used with Wisdom

Where does *The Tech* stand after 100 years? "We wield a certain amount of power," says Stepanie. "People listen. We are responsible to the community but can't let them dictate. And we can't toy with that responsibility. We have to realize our influence." When used with wisdom, that influence is appreciated. Steve remembered when he got a call from an anonymous faculty member who said that he was surprised at the grasp *The Tech* had of campus issues. "I would like to feel that at some point," he said, "as a result of reading *The Tech*, the average student stopped for a minute and thought what he was doing, why, and where he was. Then I would be satisfied.

Mr. Saltz: "There are the usual goals of a newspaper person: being fair, getting all the stories. It may seem a cliche, but it's not. Newspapers are in a special position in our country, and *The Tech* is in a particularly special position at M.I.T. As a newspaper large things are expected of us — and we expect even more of ourselves. Lots of times we don't come close to our goals, but it's important to still remember what we're trying to do.

We realize that we're guardians of student record and student opinion. Sometimes it's a very frustrating position. But when we come close to being what we want, it is extremely rewarding."

What would they like to accomplish? "It's like the camping adage," he said after a pause: "Leave a campsite better than you found it. Our campsite is the M.I.T. community and *The Tech* itself." — *M.L.*

Paul E. Gray, '54, provided a special occasion for the M.I.T. Club of Southern California when he made his first appearance as president of M.I.T. in Los Angeles on November 17, 1980. With him: (left) Samuel E. Lunden, '21, a life member of the club's Board of Directors, and (right) Burkhart Kleinhofer, '39, president of the club. (Photo: Robert D. Blake)

Riding the Wave of the Future, Says President Gray

A wave is cresting under M.I.T. today, says Paul E. Gray, '54, the Institute's new president. Young people see in the Institute "a particular kind of relevance, an opportunity for an especially powerful foundation for the kind of things they want to do," Dr. Gray told members of the M.I.T. Club of Southern California late last year.

Among the evidence cited by Dr. Gray at an "evening with the new president" session for Southern California alumni:

☐ Some 5,600 final applications for admission came to the Institute in 1979-80 for what was ultimately a freshman class of 1,050. This number contrasted markedly with the 4,000 applicants in 1973-74, and Dr. Gray said the number in 1980-81 will almost surely exceed the 1979-80 figure.

☐ Graduate enrollment is 300 higher this year than last — an increase that was "not expected or planned," Dr. Gray said, "and I don't think we understand yet quite how it happened."

Thus M.I.T. is now at about its historical peak in terms of size, with 9,000 students on the campus; and for the first time in history there are a few more graduate than undergraduate students. Yet, Dr. Gray said, "it is not our intention to let the size of the student body grow or to allow the balance between undergraduate and graduate students to change very much." Undergraduate education, he said, "occupies a high priority in the activities of the faculty, and it is a priority that we should continue to emphasize."

To illustrate this commitment Dr. Gray cited M.I.T.'s support of the Undergraduate Research Opportunity Program (UROP), "the most significant and important educational innovation seen at the Institute in the last 30 years." The program, which now involves nearly 60 percent of all undergraduates, allows students to work in partnership with faculty or research staff on real problems in science and technology, starting very early in the students' experience at M.I.T.

"Our educational purpose is, after all," Dr. Gray suggested, "to bring youngsters as early as we can to a point where they are independent of the need for the formal educational process — to the point where they are not dependent on teachers, classrooms, textbooks, lesson plans, and problem sets."

Does pass/fail grading for freshmen serve that purpose of achieving independence and confidence for undergraduates? asked an alumnus. Dr. Gray admitted that "if anybody deserves either the blame or credit for its installation 12 years ago, I do." The system, which dictates that all freshmen be graded on a pass/fail basis in every subject they take, was adopted, he said, because it seemed that the transition from secondary school to M.I.T. was for many students so traumatic that they failed to explore the Institute's many intellectual opportunities; the pressure of letter grades was not helpful.

For example, said Dr. Gray, "the thought of receiving a C and then of explaining it to parents and teachers back home . . . was far worse in its impact on a student's self-confidence than the reality of what he was or was not learning." Twelve years of experience with pass/fail suggest it is beneficial and that students today are working no less hard because of it, Dr. Gray said. — *Suzanne Olson* ☐

Do you have any advice for M.I.T. students on careers? On summer jobs? On permanent employment?

The Career Planning and Placement Office and the Alumni Association want to locate alumni willing to share career experiences, advice, and/or summer or permanent job opportunities with students. Inquiries from interested alumni will be welcomed by Elizabeth Reed in the Career Planning and Placement Office, Room 12-170, M.I.T.

The Alumni Fund Soars Ahead, but Two Computations Find It Sorely Lacking

A substantial success appears to be in the making for the 1981 Alumni Fund. Both the number of donors and the average gift were ahead of all previous records as 1980 ended, and it began to seem that President Paul E. Gray's conundrum asked of the Alumni Council on October 27 might have at least a partial answer.

The conundrum went like this: For at least 50 years the difference between the cost of an M.I.T. education and its price has been a ratio of between 1.8 and 2.2. "What this means," Dr. Gray told the Alumni Council, "is that every student at M.I.T. received through the institution a hidden scholarship which was roughly equivalent to what he or she paid in tuition.

"That hidden scholarship was the direct result of the munificence of generation after generation of friends and alumni of the Institution, who in the years before you and I were here put money into the endowment to make possible an educational program that costs about twice as much per student as we charge in tuition. "It seems to me that there is an obligation to pay it back.

"The conundrum, the thing that I just can't get my head around, is the enormous disparity between that and the number which was the median gift to the Alumni Fund last year — about $28."

It was the same basic message that John J. Wilson, '29, who was then secretary of the Corporation as well as his class' 50th reunion special gifts chairman, tried to put across at a dinner with his classmates in the President's House, then occupied by Dr. and Mrs. Jerome B. Wiesner. But Mr. Wilson's computation, unreported until now, added at least two more sophisticated factors that could only have been the product of a successful businessman's acumen.

On that occasion Mr. Wilson supplied every guest with pad and pencil to be used in setting down a "sort of personal balance sheet." Here are extracts from Mr. Wilson's instructions to his classmates:

"First of all, in the top left-hand corner of this personal balance sheet, write your current assets — cash in the bank, readily marketable securities. And an item that everyone of us has carried around with us since the day we left this place — the current cash value of our M.I.T. education.

"Next list your fixed assets — house, cars, furnishings, and the like — at cost. And another value we often overlook — the cost of your M.I.T. education. And would you believe that was only $1,448 for four years, tuition and fees included? But that wasn't the total cost. You see, the real cost was another $1,500 which the Institute put in out of the endowment accumulated as a result of the generosity of people who came before us. (And that did not count the capital cost of that machinery we were using.

"Now to the current — or short-term — liability side. You have the light bills, the gas bills, and whatever other bills come due every year, including taxes of course. One item in this list ought to have been there for every year for every one of us, and that is the M.I.T. Alumni Fund.

"Now we come down the liabilities side to long-term liabilities, otherwise known as long-term debt; and *this* is the *nitty-gritty* part. Remember the part the Institute put in out of its endowment and gifts to pay for the half of our education we didn't pay for? President Samuel Stratton should have told us, as we walked across the stage at Symphony Hall (and I don't know why he didn't')! 'You owe us this money, and you jolly well better get around to paying it back.' Now I've gone back into the records, and with interest at the prime rate, the best credit rate in the country, that $1,448 that M.I.T. put up for our education comes out to $23,845 just in interest alone, with not a nickel to reimburse the capital expenditure."

For most of Mr. Wilson's audience, the M.I.T. portions of these balances were not in balance at all — the current cash value of an M.I.T. education and the long-term liabilities were in no way offset for most classmates by their tuition payments and their Alumni Fund contributions.

But the ledger came closer to balance that June, when the Class of 1929 turned in a 50-year gift of over $1 million.

New assignments and new faces were the occasion for this "family portrait" of the Alumni Fund staff late last year. In the center, Joseph S. Collins, director. Around him clockwise: Joseph Recchio, administrative assistant in charge of the Corporate Matching Gifts Program; Brenda L. Hambleton, '79, assistant director in charge of telethons and several other solicitation programs; Nancy L. Russell, associate director, who has major responsibility for reunion gift and personal solicitation efforts; Roberta Carrara, who joined the staff last fall to be coordinator of internal programs (especially direct-mail solicitations); and Mary K. Kyger, assistant director of the fund with special responsibilities for donor recognition and programs directed to young alumni. (Photo: Calvin Campbell)

To China This Spring

An unusual opportunity to visit the People's Republic of China with Chinese alumni as hosts awaits a limited number of alumni from April 24 through May 15 under tour plans being completed by Leonard F. Newton, '49.

The three-week tour will include five days in Beijing (Peking), four days in Shanghai, three days in Kunming, one day in Guanzhou (Canton), and four days in the gateway city of Hong Kong. U.S.-based Chinese alumni will provide orientation in advance.

For information, write the M.I.T. Alumni Center of New York, 40 East 41st St., New York, N.Y. 10017; or call 212/532-8181.

Under the Domes

As he called on recipients of the 1980 Corporate Leadership Awards to stand at the Faculty Club luncheon in their honor on December 5, Howard W. Johnson, chairman of the Corporation, told them that their awards "recognize corporate leadership as a form of high public service" which plays a central role in "strengthening our economic system." (Photo: Calvin Campbell)

41 Honored for Corporate Leadership in the Public Interest

It was in 1976 that the M.I.T. Corporation established the Corporate Leadership Award for alumni "whose current responsibilities in private industry as heads of their companies mark them as exceptional contributors to the strength and well-being of this nation."

Since then 230 alumni have been given the award — the latest a group of 41 to whom presentations were made following the regular meeting of the Corporation on December 5. Some 75 percent of M.I.T. alumni seek their success in the corporate world, said President Paul E. Gray, '54, in introducing the award ceremony, and for many of these "corporate leadership is a capstone of their careers."

In its original resolution, the Corporation said it sought by the award "to express its esteem and abiding appreciation to M.I.T. alumni everywhere who further the public interest through exemplary conduct of corporate enterprise."

The 41 additions to the roster as of December 5 included:

Marvin A. Asnes, '49, president of Becton, Dickinson and Co.
Michel L. Besson, S.M.'60, vice chairman, chief executive officer, and director of Certain-Teed Corp.
Oliver C. Boileau, Jr., S.M.'64, president of General Dynamics Corp.
Amar G. Bose, '51, chairman of Bose Corp.
David A. Bossen, '51, president of Measurex Corp.
Robert H. Brown, '54, president and chief operating officer of Belding Heminway Co.
Frederick J. Bumpus, '51, president and chief executive officer of Arkwright-Boston Manufacturers Mutual Insurance Co.
John K. Castle, '63, president and chief operating officer of Donaldson, Lufkin and Jenrette, Inc.
M. Todd Cooke, M.C.P.'47, chairman and chief executive officer of the Philadelphia Savings Fund Society
Alexander V. D'Arbeloff, '49, chairman and president of Teradyne, Inc.
Richard E. Disbrow, S.M.'65, president of American Electric Power Co., Inc.
Charles J. Fisher, '46, president and chief operating officer of Reliance Universal, Inc.
Joseph S. Gaziano, '56, president, chairman, and chief executive officer of Tyco Laboratories, Inc.
George N. Hatsopoulos, '49, president of Thermo Electron Corp.
Howard H. Kehrl, S.M.'60, vice-chairman of General Motors Corp.
* Curtis M. Klaerner, '56, president of Commonwealth Oil Refining Co.
William A. Krivsky, '51, president and chief operating officer of Compo Industries, Inc.
Charles M. Laidley, S.M.'65, vice-chairman of the Canadian Imperial Bank of Commerce
Carroll M. Martenson, S.M.'54, chairman and chief executive officer of Criton Corp.
David J. McGrath, Jr., '59, president of TAD, Inc.
George J. Michel, Jr., '53, vice-chairman and chief financial officer of Stanadyne, Inc.
Robert L. Mitchell, S.M.'47, vice-chairman of Celanese Corp.
William P. Murphy, Jr., '48, chairman of Cordis Corp.
Gerald G. Probst, S.M.'56, president and chief operating officer of Sperry Corp.
Donald G. Raymer, S.M.'60, president of Central Illinois Public Service Co.
* John H. Richardson, '59, president of Hughes Aircraft Co.
Denis M. Robinson, '31, chairman of High Voltage Engineering Corp.
Frederick J. Ross, Jr., '46, president and chief executive officer of Raybestos-Manhattan, Inc.
Harold V. Rover, '45, vice-chairman of SSC&B, Inc. Advertising
Peter M. St. Germain, '48, managing director of Morgan Stanley and Co., Inc.
Herbert L. Shuttleworth, '37, chairman of the board of directors, Mohasco Corp.
Philip Spertus, '56, chairman of Intercraft Industries Corp.
Francis M. Staszesky, '42, president and chief operating officer of Boston Edison Co.
Raymond S. Stata, '57, president of Analog Devices, Inc.
John Sterner, '33, vice-chairman of Cordis Corp.
Davis P. Thurber, S.M.'48, chairman of the Bank of New Hampshire (National Association)
Sidney Topol, '50, chairman, president, and chief executive officer of Scientific-Atlanta, Inc.
Jerome E. Vielehr, '56, president of Joseph Schlitz Brewing Co.
William D. Walther, '50, president and chief operating officer of Dayton Walther Corp.
Robert H. Welsh, '48, vice-chairman of Ludlow Corp.
Kevin G. Woelflein, '54, president of the UBAF Arab American Bank
* Program for Senior Executives

Kerrebrock to Washington for NASA

Professor Jack H. Kerrebrock, who's been head of the Department of Aeronautics and Astronautics for just two and a half years, will go to Washington June 1 to become associate administrator of the Office of Aeronautics and Space Technology at NASA headquarters.

Technology Day: The Automobile

Can the U.S. automobile industry survive? If so, in what form? And what will be the form of its products in the rest of this decade?

For the answers, come to Technology Day 1981 on June 4 and 5, when a panel of experts will examine the current state of the industry in such contexts as international competition, the U.S. economy, government regulation, and automation.

A highlight in addition to these panels will be "Tech Night at the Pops" on June 4, preceded by a Sala de Puerto Rico buffet.

"The Bather," an abstract bronze by Jacques Lipchitz, has joined four other Lipchitz sculptures in the Hayden Memorial Library courtyard, a gift of the late artist's wife in honor of Paul Tishman, '24, and his wife Ruth. Speaking for them both, Mr. Tishman told members of the Council for the Arts at M.I.T. that it was "the most extraordinary birthday present we have ever received." And President Emeritus Jerome B. Wiesner, chairman of the Council for the Arts, welcomed the sculpture to the M.I.T. collection: "By joining intellect and emotion, the work presents a dual challenge to our understanding," said Dr. Wiesner. "Generations of students will see in it the meaning of the world around them." (Photo: Calvin Campbell)

You Can Lead Students to the Arts, but Must You Make Them Drink?

"I don't have time to keep up with my piano!"
"I wish I could take more!"
"I don't have time . . ."

After reading questionnaires completed by 700 M.I.T. undergraduates, Michael Good, '79, has the "overwhelming sense" that there is plenty of interest in the arts at M.I.T. "But participation is stifled," he told members of the Council for the Arts last fall, "by the pressure of academic demands."

Members of the Council, gathered for their annual meeting on November 21, responded with a series of suggestions: "Taking time for the arts surely wouldn't foreclose a student's chances for a Nobel Prize." "If the faculty fails to permit the full development of the students, that's nothing short of a crime against the artistic soul!" "Do we disenfranchise students interested in the arts by student aid policies that require them to offset expenses with summer earnings?"

But such oversimplifications were quickly laid to rest by participants in an afternoon panel. The pressure to work in the summer is vocational as well as financial, said Mr. Good; if financial needs are even partly responsible for students' foresaking the arts, they're as operative during the term as during the summer.

Curriculum changes are no panacea, said Dean Harold Hanham of the School of Humanities and Social Science. Students interested in performing arts need rehearsal time, while those interested in drawing need "time of a very different kind. . . . I would hate the notion of required courses in the arts — some students just want to play the piano by themselves."

The fact that there is a large group of serious professional students in the arts now at M.I.T. is an important factor by itself, said Professor Francis M. Low, provost. That alone goes a long way to assure that students not yet committed to the arts "establish a lifetime interest and understanding" in them. Why does it matter? Because, said Professor William L. Porter of the Department of Architecture, "arts are an unsettling experience" for many M.I.T. students — "an exposure to issues with which they are uncomfortable" because the standards are not absolute and quantitative but subjective and qualitative.

Part of the problem at M.I.T., said Professor Porter, is "to legitimize a role for the arts. Courses are legitimate but hobbies are not. We need to manipulate the boundaries and symbols of legitimacy to give the arts a larger role in more students' lives."

Wanted: More Women — But Perhaps Not More Help for Them?

Alumni looking in on a lecture in Room 10-250 these days might well be "amazed" to see as many as 50 women in a class of 250 students, says Stephanie Pollack, '81, general manager of *The Tech*. The figures — close to 1,700 women, 900 of them undergraduates — are "astounding when compared to those of a decade ago." Indeed, Ms. Pollack wrote in a recent issue of *The Tech*, "as many women have graduated from M.I.T. in the last half dozen years as in the whole history of the school up until then."

But no one — least of all Ms. Pollack — wants M.I.T. to rest on its laurels; there is general agreement that there should be more women here, she says, and that M.I.T. should be prepared to provide ever-more facilities and support services — locker rooms, coed activities, counseling services — as the numbers grow.

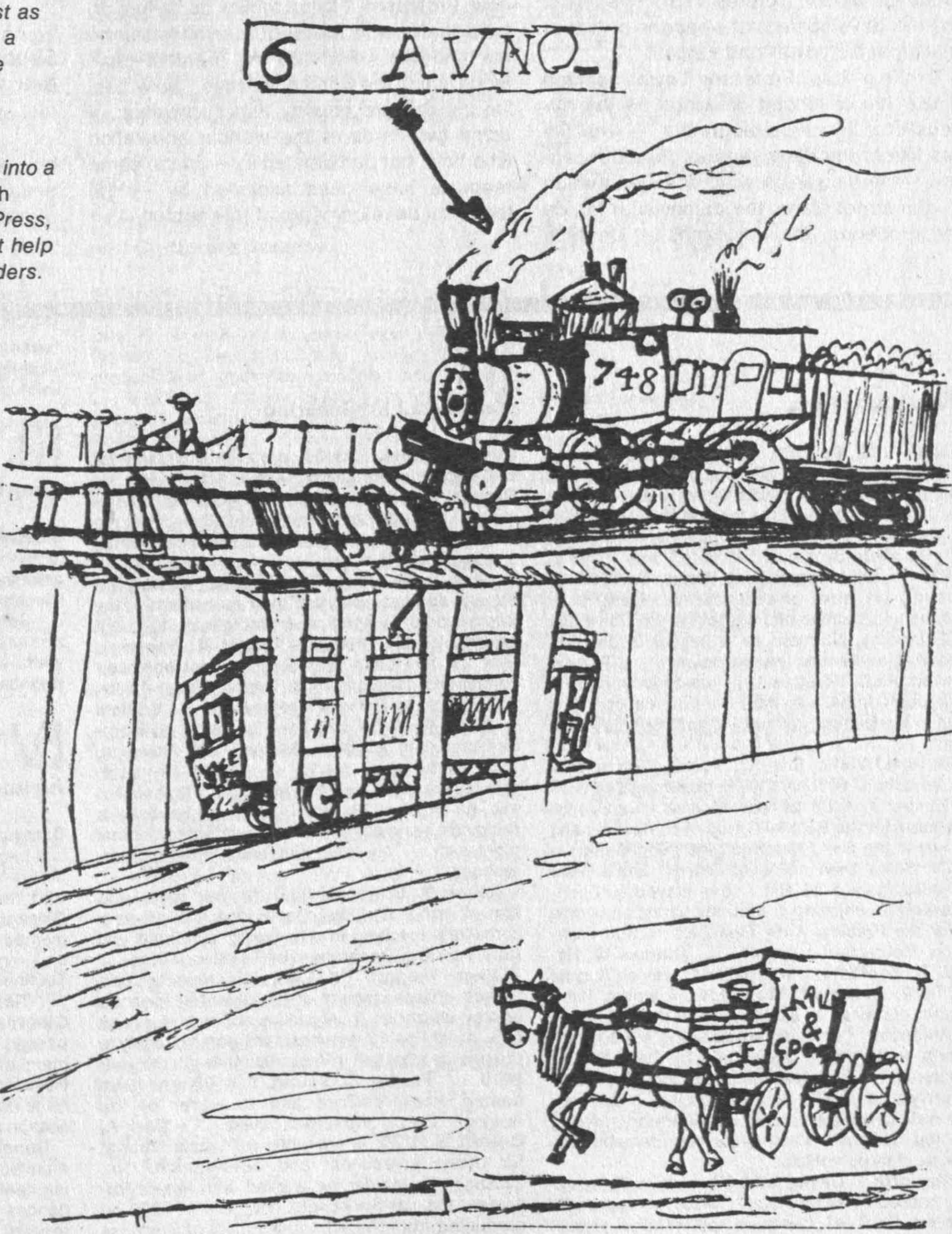
But how soon, asks Ms. Pollack, do services oriented especially to women students' needs begin the disservice of separating women from the rest of the community instead of helping them establish themselves in it? As their numbers increase, women may need fewer support services rather than more, suggests Ms. Pollack: "With respect to women's services, bigger may not be better."

Deceased

Carlton B. Allen, '02; July 26, 1980; Homestead Manor, 150 Cleveland St., Chagrin Falls, Ohio.
Annie P. Hale, '07; June 24, 1980.
Kenneth J. Campbell, '09; July 24, 1971; c/o James Brick, Trust Dept., National Bank of South Dakota, Sioux Falls, S.D.
Howard C. Fisher, '09; March 3, 1978; 21 Drowne Pkwy, Rumford, R.I.
J. Newell Stephenson, '09; November 11, 1975; Carroll County Home For the Aged, Ossipee, N.H.
William H. Coburn, '11; February 17, 1980; Fisherville Ln., Westport, Mass.
Charles F. Hobson, '11; September 23, 1980; P.O. Box 1063, Scarborough, Me.
Paul M. Tyler, '12; November 7, 1980; 1700 Third Avenue West, 920 The Shores, Bradenton, Fla.
Donald V.L. Downs, '13; September 26, 1979; 1928 DeLancey Pl. Philadelphia, Penn.
Kenneth D. Hamilton, '13; October 22, 1979; 245 Independence Dr., Chillicothe, Ohio.
Stanely H. Hodgman, '13; June 20, 1978; 2945 Pleasure Rd., Helena, Mont.
Frederick H. Kennedy, '13; 00-00-1975; 22 Perley St., Concord, N.H.
Charles C. Gager, '17; January 11, 1980; 5555 Prospect Rd., San Jose, Calif.
William B. Hunter, '17; November 8, 1980; Prospect No., Apt. C8, 633 Prospect Ave., West Hartford, Conn.
Horatio W. Lamson, '15; September 28, 1980; 72 Oakland Ave., Arlington, Mass.
Lewis P. Sanborn, '17; October 14, 1980; c/o Nancy Jones, 43 Campbell St., Norfolk, Va.
John C. Braislin, '18; November 3, 1980; 40 Firetown Rd., Simsbury, Conn.
James A. Flint, '18; October 9, 1980; 320 Ranch, Gallatin Gateway, Mont.
George F. Malley, '18; July 31, 1978; Pattenburg Rd., RD1, Box 111A, Asbury, N.J.
Frederick A. Washburn, '18; October 9, 1980; 153 Barrara Rd., Waltham, Mass.
A. Abba Orlinger, '21; September 9, 1980; 515 Foxcroft Square Apts., Jenkintown, Penn.
Theodore P. Spitz, '21; October 20, 1980; 112 Beech St., Roslindale, Mass.
Donald B. Marsh, '22; September 23, 1980; 15 Whig St., Dennis, Mass.
Welrose L. Newhall, '22; October 5, 1980; P.O. Box 47, Coraopolis, Penn.
Clarence P. Thayer, '23; August 15, 1980; 4004 W. University Ave., Gainesville, Fla.
Ronald B. Forsyth, '24; March 30, 1980; 217-A Heritage Village, Southbury, Conn.
Richard L. Holt, '24; October 4, 1980; 133 Highmount Ave., Nyack, N.Y.
Ingram Lee, '24; March 8, 1980; 3205 Southwestern Blvd., Dallas, Tex.
Leonidas C. Benos, '25; June 3, 1979; 42-30 Douglaston Pkwy., Douglaston, N.Y.
Daniel H. Keck, '25; October 10, 1980; 5402 Hampton Cir., P.O. Box 1184, Myrtle Beach, S.C.
Roger P. Moore, '25; October 25, 1980; c/o Capt. Robert S. Moore, 1582 Shadow Knolls Dr., El Cajon, Calif.
G. Graham Davidson, '26; November 5, 1980; 17 Glen Rd., Wayland, Mass.
Maurice J. Fish, '26; June 1, 1979; 83 43 118 St., Kew Gardens, N.Y.
Richard W. Frost, '26; October 4, 1980; 318 Pleasant St., Belmont, Mass.
Stuart W. John, '26; July 2, 1980; 1255 Pasadena Ave. So., 4198 Majestic Towers, Saint Petersburg, Fla.
Robert G. Maxwell, '26; September 21, 1980; 1028 Sycamore St., Haddon Heights, N.J.
Dwight C. Arnold, '27; November 29, 1980; 125 Grove St., Wellesley, Mass.
Edward Chase, '27; October 18, 1980; 27 Oak St., Plymouth, Mass.
Katherine B. Hunt, '27; October 1980; 2621 Calle Del Oro, La Jolla, Calif.
Joseph L. Collins, '28; November 7, 1980; 55 North St., Box 394, Mattapoisett, Mass.
Alva H. Pearsall, '28; June 23, 1980; Rt. 8, Box 78, Hendersonville, N.C.
Everett A. Potter, '28; September 1978; 1326 Midland Ave., Bronxville, N.Y.
Hugh G. Hamilton, '29; September 18, 1980; 1280 Royal Palm Way, Boca Raton, Fla.
Armistead Wharton, '29; July 1980; 2267 Bayou Grande N.E., St. Petersburg, Fla.
Nelson B. Haskell, '31; August 5, 1980; 3843 Lakeshore Dr., Port Arthur, Tex.
Charles H. Norris, '31; December 4, 1979; 17429 Plaza Otonal, San Diego, Calif.
R. Byram Porter, Jr., '31; October 28, 1980; 38 Middlesex Rd., Darien, Conn.
George A.W. Bisbee, '32; October 12, 1980; 303 Santa Anita Rd., Santa Barbara, Calif.
Earle F. Hiscock, '32; November 23, 1980; 543 Old Harbor Rd., North Chatham, Mass.
Ellis C. Littmann, '33; November 21, 1980; 227 Craig Rd., P.O. Box 27479, St. Louis, Mo.
James W. Vicary, '33; October 23, 1980; 219 Cherokee Dr., Erie, Penn.
Guy D. Johnson, Jr., '35; December 17, 1979; 50 Beechwood Rd., Lincroft, N.J.
George D. Frentzos, '36; June 17, 1980; 1118 Odeans Dr., Dallas, Tex.
Ellsworth I. Davis, '37; June 7, 1980; 3435 Camp St., New Orleans, La.
Thomas Garber, '38; November 6, 1980; 3 Wilson Ln., Acton, Mass.
Aram Kerkian, '38; November 24, 1980; 2947 N. Rivere Rd., Akron, Ohio.
Eric H. Smith, '39; November 10, 1979; 236B Rideau Terr., Ottawa Ont K1M 0Z2, Canada.
Joseph A. Uttal, '39; February 25, 1980; 180 Garth Rd., 4H N., Scarsdale, N.Y.
William J. Fox, '41; October 19, 1980; 1934 Edgewood Rd., Baltimore, Md.
William E. Hense, Jr., '42; August 1979.
Michael J. Hook, Jr., '42; October 30, 1980; 4310 Emmet Dr. LP, Erie, Penn.
Randolph E. Charles, '45; November 3, 1980; 76 Plain Rd., Wayland, Mass.
Walter D. Nolte, '46; September 30, 1980; 96 Red Oak Dr., Fairfield, Conn.
William M. Heyser, '47; August 31, 1979; 1819 NW 22nd St., Oklahoma City, Okla.
Casper Ranger III, '50; April 27, 1975; 13 School St., Manchester, Mass.
Daniel K. Chinlund, '50; September 19, 1980; 1150 Klamath Dr., Menlo Park, Calif.
W. Paul Jensen, '50; December 1, 1980; Rte. 3, Box 711, Idaho Falls, Idaho.
John D. Patton, '53; May 12, 1980; 613 Upper Merriman Dr., Akron, Ohio.
Richard E, Sipfle, '55; November 23, 1980; 3023 Middlebury, Birmingham, Mich.
Robert M. McGeorge, '60; May 17, 1980; 9462 Placita XICO, Tucson, Ariz.
David J. Sakrison, '61; July 15, 1980; 1515 El Sombro, Lafayette, Calif.
Walker M. Benning, '63; October 29, 1980; 1460 Miami Rd., Benton Harbor, Mich.
Edward D. Kalachek, '63; December 1979; 54 Claverach St., St. Louis, Mo.
Samruey Laobonmee, '63; 1977; 5 Prommitr Bangapi, Sukumvit 39, Bangkok Thailand.
Henry K. Dewey, '64; October 23, 1980; 6802 Rock Royal Dr., Tarpon Springs, Fla.
Elmer V. Merry, Jr., '67; November 6, 1980; Hawthorne Pl., Apt. 9-M, Boston, Mass.
Christine K. Morris, '74; August 5, 1980; 2475 Redbud Ct., San Jose, Calif.
Thomas W. Sy, '72; August 17, 1979; 1420 Vilas Ave., Madison, Wis.
Andre B. Colpitts, '74; May 21, 1976.

Professor Emeritus C. Fayette Taylor, '29, started the process of growing up just as the 20th century began, and even as a youngster in Manhattan he must have realized that he was witnessing vast changes in the way people lived and worked. Now he has gathered his childhood drawings and recollections into a book – Growing Up with the Twentieth Century *(Brookline, Mass.: Tandem Press, 24 Monmouth Court, $5.95) that can't help but bring old times for countless readers.*

See page A14.



A Chronicle of How Life Was Different as the Century Began

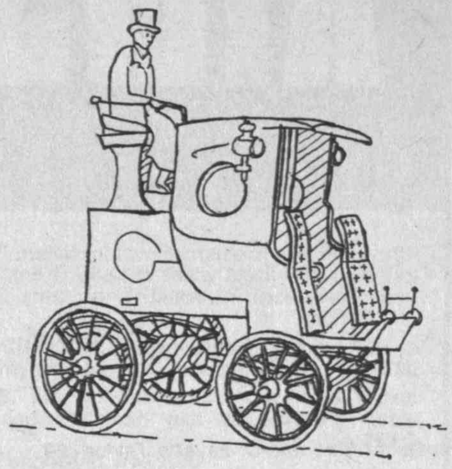
It all started when Professor Emeritus C. Fayette Taylor, '29, who taught automotive engineering at M.I.T. from 1926 to 1960, discovered a cache of childhood drawings in the family attic. They revealed a youthful "near-obsession with machinery," he says. And as he thought about it, they also represented what seemed to him an unusual "eye-witness account" of life at the beginning of a period of unparalleled technical change.

Indeed, he says, "it is hard to imagine new developments that could change our life style more drastically than have the automobile, the telephone, electric power and light, the mechanization of farming, airplanes, motion pictures, radio, television, and the development of weapons of war of unimaginable power and range."

Thinking thus, Professor Taylor decided to use his childhood drawings as the nucleus for a "technical biography" — what life was like in the early years of the 20th century, while he was growing up in Manhattan . . . the street piano, the dumbwaiter for ice and groceries, the thousands — perhaps hundreds of thousands — of horses and the street cleaners who pursued them, the vaudeville shows, the first electric-powered streetcars and then the subways . . .

The result is *Growing Up with the Twentieth Century* (Brookline, Mass.: Tandem Press, 24 Monmouth Court, $5.95), now in its second printing, which has been the object of kudos from many readers. One, cited on the cover, from Irenee du Pont, Jr., '43: ". . . absolutely the greatest! Reading it was sheer enjoyment."

Looking back from the perspective of 1980, Professor Taylor recalls that in the early years of the century "people in what we now call the developed countries were so caught up in the excitement of the technological revolution that few doubted it would bring untold benefits to mankind." But now Professor Taylor thinks its failure to fulfill that vision for all of mankind may be our undoing. "Perhaps the greatest challenge which the world now faces," he writes, "is the relative poverty and deprivation of some two-thirds of the world's population who have not participated in — and in some respects have been exploited by — the technical developments of this century."



Electric Cab
New York, 1900

I
Civil Engineering

Joseph L.M. Gagnon, S.M.'62, writes, "Those who would like some information on the James Bay hydroelectric projects in Northern Quebec can send their inquiries to me and I will try to fill in the requests. Mr. Gagnon recalls his association with the Hydrodynamics Laboratory from 1960 to 1962. . . . **Ru-Liang (Leon) Wang,** Sc.D.'65, is currently on leave of absence from Rensselaer Polytechnic Institute and has joined the University of Oklahoma, Norman, as professor of civil engineering and environmental science. . . . **Robert Lenton,** Ph.D.'74, since 1977 has been working in New Delhi, India, with the Ford Foundation in the area of agriculture, resources, and rural development.

Harry N. Wallin, S.M.'37, reports, "Since retiring from the U.S. Navy Civil Engineering Corps on November 1, 1968 as rear admiral, I worked for ten years for the Bechtel Group of companies and retired in the San Francisco area (San Mateo) in 1978. Since then my wife, Esther, and I have travelled quite a bit and I have played golf considerably — enjoying it a lot. My handicap is now 15 at the Presidio Army Golf Club in San Francisco. Retirement is great!" . . . **Thomas W. Sy,** S.M.'72, of Madison, Wi., passed away on August 17, 1979. . . . **Jerry D. Wall,** S.M.'68, writes, "I am current professor of architecture at the University of Arkansas. I am also co-directing a $200,000 energy audit project sponsored by the U.S. and Arkansas Energy departments. In addition, I have recently completed a research project in conjunction with Lawrence Livermore Laboratory, involving the service infrastructure requirements for energy storage vehicles.

Ellsworth I. Davis, S.M.'37, of New Orleans, La., passed away on June 7, 1980. . . . **James E. Ashton,** Ph.D.'65, has been appointed an assistant general manager in charge of engineering at General Dynamics-Electric Boat, Norwich, Conn.

II
Mechanical Engineering

Susan Swidler, S.M.'80, is currently working for Bell Laboratories' Quality Assurance Center. . . . **Serope Kalpakjian,** S.M.'53, notes that he received a 1980 Centennial Medallion from the American Society of Mechanical Engineers, is the associate editor of the *Journal of Applied Metalworking* published by the American Society for Metals, and has co-edited the Proceedings of the International Symposium on Metalworking Lubrication, ASME, 1980. . . . **Daniel M. Hancock,** S.M.'73, has been promoted to chief engineer, commercial transmissions, Detroit Diesel Allison Division of the General Motors Corp. . . . **William D. Mark,** Ph.D.'58, has been named a divisional vice-president of Bolt, Beranek and Newman, Inc., Cambridge, Mass. . . . **Fujio Hayaski,** S.M.'75, reports the birth of a son, Stephen Tomio, on October 28, 1980. "Although the baby is demanding and doesn't have a concept of day and night yet . . . my wife and I are enjoying parenthood."

Ashok B. Boghani, Sc.D.'74, has joined the firm of Arthur D. Little, Cambridge, Mass., as a consultant involved in developing a railroad test facility for the Department of Transportation. . . . **William Teagan,** Ph.D.'63, has recently performed an assessment of the potential for solar energy utilization in Argentina as part of a joint U.S.-Argentine government program to analyze the energy situation in Argentina through the year 2010. . . . **Fredric C. Young,** S.M.'60, has been named vice-president and treasurer of the Analogic Corp., Wakefield, Mass. . . . **Carl A. Gowan,** S.M.'76, is presently a financial analyst for Urban Investment and Development Co., Chicago, Ill.; earlier he worked with Water Resource, Inc., in Springfield, Va., and in 1980 he graduated from the Wharton School of Business with an M.B.A. degree. . . . **James R. Matthews,** Ph.D.'74, has recently transferred from the Defense Research Establishment, Pacific, in Victoria, B.C., to the Defense Research Establishment, Atlantic, Halifax, N.S.

III
Materials Science and Engineering

Michael Korenko, Sc.D.'73, is currently on leave from the Materials Research Management Program at Westinghouse with a White House Fellowship, assigned to the Department of Defense. . . . **John Zotos,** S.M.'56, has been teaching at Northeastern University, Boston, Mass., for 20 years and has been active in several technical societies in metallurgy.

IV
Architecture

Demetrois A. Criezis, M.Arch.'77, writes that he has become a registered architect in the states of Illinois and Missouri and is currently associated with the architectural firm of Perkins and Will, Chicago, Ill., as a senior architect. He is also a member of the American Institute of Architects and recently lectured at the Illinois Institute of Technology and the University of Illinois, Chicago. . . . **Randolph E. Charles,** '45, owner of the Charles Engineering Co., Waltham, Mass., passed away on November 3, 1980. He was a member of the M.I.T. Laboratory for Insulation Research in 1942-46 and again in 1961-63, and he is credited with the invention of a microwave coaxial switch and other electronic hardware.

Donald Lewis, M.Arch.'73, has started his own architecture firm, Don/Lewis Architecture, designing health care centers, medical offices and residences. . . . **Mitchell Lewis Green,** M.Arch.'75, reports, "My wife Susan and I have been living in Chicago for the past three years, and I have been promoted to senior architect in the firm of Skid-

Innovation: Regulation Turning into Control?

In 20 years government regulation has throttled innovation in the pharmaceutical industry, and it threatens to extend its grip on entrepreneurship to other segments of American industry as well. "We have institutionalized a mechanism for saying no,' and have yet to devise a means to achieve the essential purposes of regulation in a way that is affirmative and supportive to new technology," Dr. Gerald D. Laubach, Ph.D.'50, president of Pfizer, Inc., told his colleagues in the Industrial Research Institute in Washington last fall.

Some evidence from his own field of pharmaceuticals, which was the first to come under the heavy hand of government regulation.:

☐ Six of the 12 leading prescription drugs introduced into the U.S. market in the 1970s were discovered abroad. And five of the six which were discovered in the U.S. were first marketed abroad.

☐ The time needed for clinical testing and marketing approval in the U.S. has gone from about two years in the early 1960s to some nine years in 1976.

☐ In 1962 the average research and development investment in a new chemical entity brought to the U.S. market was about $4 million. By 1976 it was $54 million, and "doubtless the figure is much higher today," says Dr. Laubach.

☐ About half of the first human tests of new drugs originated in the U.S. took place abroad in 1976.

☐ U.S. drug firms are increasingly locating their research and development efforts overseas. Between 1972 and 1978, R & D personnel overseas increased by about 55 percent, according to Dr. Laubach's figures; the increase in the U.S. was only 8 percent.

Though regulation of the pharmaceutical industry was conceived in terms of managing the market introduction of new phramaceuticals, in fact it has come to represent "regulatory control over most of the R & D process . . . the process of innovation per se," Dr. Laubach said. As a result, "practically every aspect of pharmaceutical R & D" is now governed by "highly prescriptive, design-type specifications.

"Government control of the process of scientific research is a grave matter," Dr. Laubach told his colleagues. "There is a very real trend toward a state-mandated scientific orthodoxy in [the field of] therapeutic innovation.

"A fundamental change in the structure and orientation of our regulatory mechanism is . . . a requisite for the restoration of the competitive vitality of all American industry."

more, Owings and Merrill, serving as senior designer on projects in Chicago and Boston.

V
Chemistry

Mark Berch, Ph.D.'73, is currently a primary examiner at the U.S. Patent and Trademark Office, specializing in diazene pharmaceuticals and beta-lactam antibiotics. . . . **Janet S. Perkins,** Ph.D.'52, reports that she received a certificate for outstanding achievement at the Army Science Conference at West Point in June, 1980, for a paper, "Laser Interaction with TBR Materials." She continues, "In September, I had a fascinating trip to the People's Republic of China with an American Chemical Society group. From Peking, I was able to reach by telephone my former M.I.T. roommate, Hilda Chow, who is now vice director of Fundan University and professor of physics. . . . **Crist Scott Blackwell,** Ph.D.'71, has been promoted to group leader — spectroscopy and separations in the Central Scientific Laboratory, Union Carbide Corp., Tarrytown, N.Y. . . . **Robert B. Davis,** Ph.D.'66, has been promoted from associate director to a director of Albany International Research Co., Dedham, Mass. . . . **Charles V. Berney,** S.M.'54, directed the M.I.T. Community Players' production of Gilbert and Sullivan's "H.M.S. Pinafore" in May 1980. The production played to packed houses for two weekends.

VI
Electrical Engineering and Computer Science

Willard W. DeVenter, S.M.'49, has retired as captain from the U.S. Navy. . . . **Arthur L. Fox,** S.M.'72, is currently executive vice-president of Ocktek, Inc., Burlington, Mass., specializing in the production of robot vision modules and systems. . . . **Michael F. Ruane,** S.M.'73, is presently an assistant professor of electrical engineering at Boston University. . . . **Edwin Z. Gabriel,** S.M.'51, writes that he has applied for three U.S. patents on "book-sized educational analog computers" with all the features of the large computers plus additional features which will enable them to be less dependent on an oscilloscope.

Louis Weinberg, Sc.D.'51, reports, "I spent a most enjoyable sabbatical year having been bestowed a research award from the Japan Society for the Promotion of Science to conduct research on matroids in Japan." He served as a visiting professor of mathematical engineering at the University of Tokyo and also lectured at the Tokyo Institute of Technology and at universities in Kyoto, Osaka, and Tohoku. . . . **Armand R. Tanguay,** S.M.'51, reports that "the big event was to add a son-in-law and a first grandson to the family. Also, I have bought a farm and am developing it as an energy conservation project and am working for the Xerox Corp. in engineering economics." . . . **David J. Sarkison,** Sc.D.'61, of Lafayette, Calif., passed away on July 15, 1980. . . . **Mark A. Orenstein,** S.M.'68, has been appointed director in the Data Processing Department at the Travelers Insurance Companies, Hartford, Conn. . . . **Joseph A. Uttal,** S.M.'39, of Scarsdale, N.Y., passed away on February 25, 1980. . . . **Joseph Bordogna,** S.M.'60, acting dean of the School of Engineering and Applied Science at the University of Pennsylvania, Philadelphia, was presented with the S. Reid Warren, Jr., Award for distinguished teaching.

VIII
Physics

John D. Mallett, S.M.'46, has founded a new corporation, Adaptive Sensors, Inc., Santa Monica,

Calif., specializing in contracting and consulting services in radar, communications, adaptive arrays, and signal processing. ... **James F. DeBroux,** S.M.'79, graduated from the Field Artillery Officer Advanced Course and is currently battery commander, Battery C, 2nd Battalion (Airborne), 321 Field Artillery, Ft. Bragg, N.C. ... **Daniel Stump,** Ph.D.'76, is presently assistant professor of physics at Michigan State University. ... **James Witting,** Ph.D.'64, head of the Physical Oceanography Branch at the Naval Research Laboratory in Washington, is teaching at the U.S. Naval Academy this year as part of the Naval Scientist Training and Exchange Program.

X
Chemical Engineering

Two professors in the department received major awards from the American Institute of Chemical Engineers in Chicago last November:
□ **James Wei,** Sc.D.'54, the William H. Walker Award for excellent contributions to the chemical engineering literature;
□ **Charles N. Satterfied,** Sc.D.'43, the R.H. Wilhelm Award in chemical reaction engineering for his contributions in research papers and books.

Professor Glenn C. Williams, Sc.D.'42, of the department has been awarded the Sir Alfred C. Egerton Gold Medal by the Combustion Institute for "his distinguished, continuing and encouraging contributions to the field of combustion." ... **W. Paul Jensen,** S.M.'50, of Idaho Falls, Id., died in an auto accident on December 1, 1980. ... **Harvey C. Travers,** S.M.'49, is currently division manager, business development, chemical and pharmaceuticals at Treadwell Corp., New York City. ... **Stephen H. Baum,** S.M.'64, is currently president of Diamond West Energy Corp., a technology venture company with patents in energy and mineral processing.

L. Stephen Powers, S.M.'45, has been elected president of Edward H. Richardson Associates, Inc., Newark, Del., a consulting firm. ... **Maurice F. Granville,** S.M.'39, retired as chairman and chief executive officer of Texaco, Inc., and has been elected a director of the Crown Zellerbach Corp., San Francisco, Calif., a forest-products concern. ... **David H. Jones,** S.M.'65, has been promoted to vice-president — technology of the Badger Engineering Corp., Cambridge, Mass. ... **Karl F. Cast,** S.M.'41, has been advanced to corporate vice-president of Ethyl Corp. in charge of engineering, central systems, and data processing.

XII
Earth and Planetary Sciences

Brian G. Schultz, S.M.'66, reports that he is presently project manager for Stone and Webster Engineering Corp., working on the construction of River Bend Station — unit one, a nuclear power plant rated at 940 MWe. ... **Irving A. Breger,** Ph.D.'50, has retired from the U.S. Geological Survey and is now a consultant in fossil fuels. ... **Norman Sleep,** Ph.D.'73, a member of the Stanford University faculty, received the Macelwane Award of the American Geophysical Union for his work in the investigation of the physical and geological implications of plate tectonics. The citation gave special recognition to his work on thermal subsidence of passive continental margins which has gained importance in relation to offshore hydrocarbon deposits.

XIII
Ocean Engineering

James R.Z. Reynolds, S.M.'40, a retired U.S. Navy Rear Admiral, died on September 22, 1980, in Gales Perry, Conn. After retiring from the Navy in 1958 he spent 13 years with General Dynamics-Electric Boat, supervising construction and repair of nuclear-powered submarines. ... **Thomas A. Marane,** '64, writes "I am now the commander of the Pearl Harbor Naval Shipyard and another classmate, **Ernest J. Scheyder,** '64, is commander of the Mare Island Naval Shipyard. If it floats we can fix it!" ... **Francis A. Packer, Jr.,** '51, reports that he is back with Exxon International's Tanker Department, Florham Park, N.J., working on four ships being built in Taiwan.

Walter H. Cantrell, S.M.'65, became project manager for the Trident Ship Acquisition Project for the U.S. Navy on July 23, 1980. ... **Steven Buttner,** S.M.'72, has been promoted from program manager of commercial new construction and Navy overhauls to director of program management at Bath Iron Works, Brunswick, Me. ... **Beverley J. Lowe,** N.E.'58, has been named president and general manager of the Nuclear Industries Systems and Services Division of United Nuclear Corp.

XV
Management

L.R. Morris, S.M.'54, reports that he is now president of Wharton Econometric Forecasting Associates, Inc. ... **James Emery,** Ph.D.'54, writes that he has returned to the Wharton School at the University of Pennsylvania as professor of decision sciences. He had left Wharton in 1974 to work at Educom, a non-profit consortium of colleges and universities located in Princeton, N.J. ... **Paul R. Freshwater,** S.M.'68, is currently associate manager of special projects for the Procter and Gamble Co., Cincinnati, Ohio, and vice-president of the Charter Committee of Greater Cincinnati.

J. Scott Armstrong, Ph.D.'68, is presently on leave from the Wharton School of Business, Philadelphia, Penn., as a visiting professor at IMEDE, Lausanne, Switzerland. ... **Perry Cohen,** Ph.D.'71, reports that he is self-employed as a management consultant in Washington, D.C., where he lives with his wife, Rosalie, and one-year-old daughter, Shayna. ... **Vincent S. Castellano,** S.M.'77, is currently an associate at Goldman, Sachs and Co., specializing in private placements, project financing and leases. ... **Donald E. Dallas,** '60, has been named president of Dynetics Corp., Woburn, Mass.

Sloan Fellows

Irving Skorka, S.M.'69, has been appointed program director of the Rapport III Program for the Belgian Air Force. ... **Peter J. Wolfe,** S.M.'73, has been named senior vice-president of Citibank, heading International Services Management for the Financial Institutions Division of Citibank's Institutional Banking group. ... **Gary Frashier,** S.M.'70, has joined Millipore Corp. as president, international operations, Bedford, Mass. ... **John D. Patton,** '53, of Akron, Ohio, passed away on May 12, 1980. ... **Daniel K. Chinlund,** '50, passed away suddenly on September 19, 1980. ... **Franklin W. Mohney,** S.M.'61, formerly corporate vice-president of Chicago Pneumatic Tool Co., is now president and chief operating officer of Northwest Industries' General Battery Corp.

Senior Executives

Charles R. Sitter, '68, has been elected executive vice-president of Esso Europe, Inc., a unit of the Exxon Corp. ... **Bennie L. Franks,** '72, was named president of Sun Texas Co., a new division of the Sun Oil Co., Inc., formed from the acquisition of the U.S. oil and gas properties of Seagram Co. ... **Raymond F. Pettit,** '70, has been elected vice-president and chief financial officer of the Colgate-Palmolive Co., New York, N.Y.

08

We have been informed of the death on June 27, 1980, of **Chester A. Brown**, architect. His death was in Winter Park, Fla., where he had lived since 1974.

Chester was with the Boston firm of Cram and Ferguson for about 50 years; he retired as a partner in 1957. He participated in the design of many buildings including the East Liberty Presbyterian Church of Pittsburg, the Cathedral of St. John in New York City, and various buildings at the Military Academy at West Point, Phillips Exeter Academy, Wheaton College and Boston University. He was a member of the Unitarian-Universalist Church in Winter Park, and of various architectural societies and clubs. He is survived by his widow, Margaret L. S. Brown, and by three sons, six grandchildren, and one great-granddaughter. He was 96 years of age. — **Harold S. Osborne**, Secretary, 375 Highland Ave., Upper Montclair, NJ 07043

13

I am wondering if the prediction of another mild winter is coming true. We have had many robins staying in Maine through November, and that is supposed to mean "not much snow!"

We received the following note from **Allen F. Brewer**: "Just two more weeks and we are over the hurricane season for this year. Our fingers are crossed till November 1. Fortunately we have led a charmed life down here this year — not even a wisp of wind. So we installed our new protective awnings to no avail, except that they shade the house and possibly help to reduce the power costs. We both continue in good health. At least that's what the medicos tell us. Since I am nearing my 91st birthday in June, they may be right. Now we are both looking forward to the 1983 reunion.

"I am continuing to write verses for the local newspaper, the *Mirror*, in Jensen Beach. I'm enclosing my latest, "Education," which could be of timely interest:

Oh, it's nice to be receiving
Of a gift of priceless worth,
Education, in this modern age of ours.
Abe Lincoln realized this gift
And studied law at night,
In that cabin in the woods by candlelight.

But always just remember you can't get those hours back,
Which are spent in trivial talk or thoughtless acts;
For the "goose that laid the golden egg"
Is subtle in its meaning,
If we kill that goose no eggs will be forthcoming.

So remember what you're here for.
Don't throw tantrums just for sport.
Young ideals can dull with aging
When they lose their true import.

For the world won't stop revolving,
Tho it may seem somewhat tiring,
You'll be needed when you grow up
With the knowledge you're acquiring."

We have been notified by the Alumni Office of the death of **Robert P. Smith** on November 30, 1979, and of **Harold E. Crawford** on June 28,1980. Harold is survived by his wife, Mary Bassett Crawford, and a daughter, Martha Gray. — **Rosalind R. Capen**, Assistant Secretary and Treasurer, Granite Point Rd., Biddeford, ME 04005

14

Roswell F. Barratt and Mrs. Charles Francis Robbins were married on September 13, 1980, in the chapel of Trinity Church, in Southport, CT, the town in which Ros has lives for many years. His note with the announcement reads, ". . . my best girl of 60 years ago. . ." I wrote Ros that we all wish them both many years of happiness together. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, CT 06119

16 65th Reunion

We had a delightful class luncheon on November 19 at the M.I.T. Endicott House in Dedham, Mass. We were very pleased with the facilities and the location and unanimously agreed that we will hold our 65th Reunion at this site. The dates are June 3-5, 1981. The Endicott House is ideal for a group of our size. M.I.T. will provide us with bus transportation to and from Symphony Hall for our attendance at the Pops concert on Thursday night and again on Friday so that we can attend the Technology Day luncheon. Overnight accommodations are available for all those classmates and their guests who request them. We encourage everyone who can to come to part or all of our reunion. Your reunion committee will make whatever arrangements are necessary to help you attend this reunion no matter what your need is. Challenge us. We will come up with the answers.

Classmates present for our luncheon on November 19 were Frances and **Paul Duff** and their daughter, Sheila; **George Crowell** and his son, Bob; Frieda and **Hy Ullian**; Frances and **Henry Shepard**; Anne and **Izzy Richmond**; Sibyl and **Ralph Fletcher**; **Barney Gordon**; **Milton Schur**; **Doug Robertson**; and **Nat Warshaw**. All looked well and are enthusiastic about our 65th. Joe Martori, director of reunion planning for the Alumni Association, spoke to us briefly about the activities which will be available to us at the time of our reunion.

We had responses from many of our classmates who couldn't make the luncheon. Dorothy and **Dave Patten** were scheduled to attend but called that morning indicating they couldn't come. Grace and **Dan Comiskey** also were coming to the luncheon but had to cancel at the last minute. **Francis Stern** called to indicate that while his health has improved substantially he could not drive up from Hartford for this event. He sent his best wishes to all, said that Gladys was well, and that they both are looking forward to joining us for our 65th. **Don Webster** wrote that he was hospitalized for surgery in late August and was doubtful about making the luncheon. He and Marjorie send their best to all. **John Fairfield** wrote: "Sorry it seems too arduous." **Charles McCarthy** wrote: "Hope you have a happy day." **Charlie Reed** wrote: "Wish I could come, believe we'll make it for the 65th." **Allen Pettee**: "Your stewardship deserves better recognition than this but it is hard enough to get to see my children (all in the North) and to find a way to take part in family affairs." **Art Shuey**: "Hope to be with you at our 65th." **Shatswell Ober**: "Endicott grounds are wonderful in spring."

Talked with **Cy Guething** on the phone, and he seemed well and busy and getting ready to have a family gathering at his home for Thanksgiving. . . . This note from **Val Ellicott**: "My wife and I have been at Broadmead (Colkeysville, Md.) for almost a year. It is a new lifetime care residence built by the Baltimore Quakers. We like it very much." . . . From **Ed Parsons**: "We are at our house in Islamorada, Fla., from November 1 to May 1, and in Jamestown, R.I., the other six months. We swim all winter on Plantation Key and fish every time we have a chance for blue fish off Block Island in the summer. If any classmates look us up we would be more than happy to welcome you."

John Gore's daughter writes: "My Dad had a stroke in June, and has been hospitalized since. He always enjoyed reading the M.I.T. reunion news, and letters from you all at various times. He enjoyed the world series ballgames. Now, however, he has difficulty swallowing, so is on I.V. He likes us to read the cards to him and tell him the news. Although he wishes he could, he will not be able to attend any more meetings or reunions but sends his best wishes to you all." Within a few days after receiving the above letter, John's daughter called to say he had passed away.

Joel Connolly: "Thank you for all you are doing for us! If Reagan does as well as president as you are doing, the country will be o.k." Keep the letters coming and (as **Cy Guething** says) "keep breathing," and (**Nat Warshaw** says) "keep walking." — **Ralph A. Fletcher**, Acting Secretary, Groton Rd., W. Chelmsford, MA 01824

17

With sorrow announcement is made of the death of **Bill Hunter** who died on Saturday, November 8. He had been ill for some time, and it was hoped

Late last fall Class of 1916 met at Endicott House to plan activities for their upcoming 65th Reunion in June. Seated left to right are Ralph Fletcher and Izzy Richmond. Standing are Bob Crowell, Geroge Crowell, Nat Warshaw, Henry Shepard, Barney Gordon, Frances Shepard, Doug Robertson, Milton Schur, Bob O'Brien, Anne Richmond, Sibyl Fletcher, Hy Ullian, Frieda Ullian, Frances Duff, Sheila Duff and Paul Duff.

that clearing a stoney gall bladder would help him. But the operation disclosed an advanced liver cancer that had not shown on X-rays, and he lived but a short time after the operation. He had been the class catalyst for a long period and will indeed be missed. His memorial service was held in the Immanuel Congregational Church in Hartford, Conn., on November 15. Bill and Doris had been active church persons there for years. As class secretary Bill had sought and got news. He took his membership in the Alumni Council seriously, attending meetings with Doris whenever possible. We are grateful for his life fellowship. **Ray Stevens**, **Jess Rogers**, Jeannette and **Stan Dunning**, Phyl and **Don Severance** attended. Memorial gifts may be made by checks to the order of Massachusetts Institute of Technology 1917 Memorial Fund.

Frank Butterworth writes on the stationery of the Butterworth Industries, Inc., of Marion, Ind., that his son now runs the business but that he, Frank, is at the office every day with his hobbies — coins, plates, stamps and First Day Covers. The hospitalizations that prevented his joining the 62nd Reunion did not amount to much — just a few days for vertigo. He writes, "I wonder if the other '17ers feel as I do about the Northfield Inn, where we spent many happy hours. This was one of the few remaining 'New England Inns,' and why the natives destroyed it I'll never know."

"**Coak**" **Coakley** writes from Richmond that he has been well except for some deterioration of eyesight (macular deterioration of the retina) which they say progresses slowly. He reports, "We gave up a private home and are living in an apartment complex that is as satisfactory as such a set-up can be but not like one's own home. This year we have had a cruise to Bermuda, a plane and a bus tour of Canyonland, Ariz. (beautiful!) and spent a couple of weeks in September at Myrtle Beach, S.C." Four collegian grandchildren and one great grandson help them to keep a young outlook. Allied Chemical, where he spent his whole career, has almost completely changed, and "all the crowd I knew are gone. They have almost dropped out of the chemical business and are more or less a conglomerate." He hopes to make the 1982 reunion, and suggests that as travel gets more difficult, the reunions should be located handy to planes or other public transportation.

Stan Chisholm writes from San Diego that he is still more or less immobile from a surgical mishap 17 years ago, but he can report on his children. With three children, six grandchildren, and two great grandchildren there is much family activity. He read much about **Jack Wood**, whom he remembers from the 1916 Tech Show as a ballet queen (Stan played the violin in the show orchestra). Stan also writes that "it has been 20 years since I was back East, and in the years since 1917 my contacts with the 1917ers are probably less than a score, due to my moves, but I still look forward to something that rings a bell in the class notes."

Similarly, **David Atwater** writes from Westfield, Mass., that two years after a serious operation he is still confined to his home with walking difficult, but improving, and he "looks forward to *Technology Review* and some mention of someone I know."

Bill Eddy (officially Harrison Prescott Eddy, Jr.) and Mrs. Eddy reside quietly in Manchester, Mass. They dropped golf some time ago and even gave up their ketch and sailing, but Bill still walks the shore two or more miles most days, still drives his car, but never goes into Boston or Cambridge. Bill chops wood when walking bores him. A married daughter, a psychologist, has two sons, and they have a son in New York. Bill's retirement is complete.

With regret we record the deaths of several other classmates. Dr. **Victor Dolmage** died at Vancouver, British Columbia, in June 1980. He received his doctorate in geology from M.I.T. and spent 47 years in that field, mostly in western Canada. **Roland H. Eaton** died at Sudbury, Mass., on September 8. He served in France with the 37th Engineers and spent many years with the Factory Mutual Group. **Charles E. Plummer** died at San Diego, Calif., on October 23. **Archibald B. Johnston**, metallurgist, died at Bethlehem, Penn., on September 18.

A new estate secretary was needed, so by executive order **Phil Cristal** becomes estate secretary, and the undersigned start functioning as class secretaries, anticipating notes from all of you. — Secretaries Pro tem: **Raymond S. Stevens**, 100 Memorial Dr., Cambridge, MA 02142 and **Stanley C. Dunning**, 33 Christian Ave., Box 218, Concord, NH 03301

18

There is a complete dearth of news, with no communication from any of you this past month.

Your secretary and Selma spent a few days in Bermuda at the Inverurie Hotel where we honeymooned fifty years ago. The island is beautiful with flowers, shrubs, and the landscape always in bloom. The houses are clean and the stucco exteriors are painted in fresh, appealing colors. Compact autos and mopeds whiz about, but no large cars. And, of course, there is the ocean with all the inlets — most attractive with the clear blue water.

I was impressed with the friendly people — multiple races with a minimum of discrimination. There is no poverty, no ghettos, no sales tax, no income tax, and a high standard of living. All of this without heavy industry. The income is largely from tourism. Maybe we should study their system. — **Max Seltzer**, Secretary, 1443 Beacon St., Brookline, MA 02146; **Leonard Levine**, Assistant Secretary, 514 Washington St., Brookline, MA

Class of 1921 celebrate their mini-reunion in North Chatham, Mass., on Cape Cod late last summer. They are (left to right) Whitney Wetherell, Hazel Wetherell, Helen Miller, Al Lloyd, Emma Lloyd, Leila Lunden, Sam Lunden, and Bob Miller.

19

I had the pleasure of a surprise telephone conversation with **Everett Doten** at his home in Detroit, Mich. He is in good health and spirits and is looking forward with anticipation to our 65th Reunion. He told me of a classmate, **Robert Insley**, who has just moved into a neighboring apartment. I am told Robert is doing well also except for some eye troubles. I told Everett that our living classmates are not staying home these days; I had called three of them repeatedly without an answer until I called him. I will keep trying.

Don Way attended the funeral recently of Bill Hunter who was the secretary of the Class of 1917, and I mention it because some of you may have known Bill from his class activities while we were together at M.I.T.

Many of you will remember **Jimmy Reis, Jr.**, of our class. He died in Pasadena, Calif., on May 30, 1980. I have no further details at this time. I am also informed without any details of the death back in February 1978 of **Joseph Higgins**, a classmate of long residence in Allston, Mass. **John O. Merrill** died on September 19, 1980. He was a long-time resident of Melrose, Mass., and I believe like many others in those war years was associated with both the class of 1918 and 1919.

It will be 1981 when you read these notes and I wish you all a happy holiday season and a happy new year. — **W.O. Langille**, Secretary, Box 144, Gladstone, NJ 07934

20

Our distinguished classmate, **George B. Morgan**, is considered the dean of educational counselors, and due recognition was given him at the Alumni Officers Conference when the George B. Morgan Award was given to nine Educational Council members. George has been involved with the Council since its beginning in 1950 and remains active in the affairs in south Texas.

John B. Garrett of 25 Brahms St., Roslindale, Mass., died on October 4, 1980. He completed post-graduate studies in 1920 and was appointed to the M.I.T. faculty. He was named chief bacteriologist for the V.A. hospital in Tuskegee, Ala., and remained there until his retirement in 1954. He was a member and officer of the American Tennis Association and a visiting aide for the Commission of Affairs of the Elderly. He leaves his wife, a son, and two granddaughters.

Ray Reese of 3821 Sulphur Spring Rd., Toledo, Ohio, died May 1, 1980.

Ming Pai has given up his Washington, D.C., address to live with his son, Dr. Coda Pai. Ming does not give us his son's address, so this is a request for that information as we do not want to lose touch with this popular classmate.

A word from **Frank Maconi** of Leominster indicates that he is active in the Tri City Score Chapter and is serving on his church finance committee. When last seen at the Woodbine Cottage eating place in Sunapee, N.H., Frank certainly looked hale and hearty. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, MA 01890

21 60th Reunion

A letter in late October from **Whittier Spaulding** told of the death of his close friend **Charles E. Thornton** of North Andover, Mass., on September 18, 1980. "Charlie and I had been very close as undergraduates and our paths crossed in business several times. He worked for Westinghouse in the '20s, for a gas company north of Boston in the '30s, was with the Maryland Public Service Commission in the '40s, and finished his professional career with Stone and Webster. Our two families were very close; we stopped a number of times at their winter home on Jekyll Island and they visited us in Boothbay Harbor." Whit reported returning to Sarasota in September after a fine summer in Maine. He and Beth are trying to sell their Boothbay cottage — "too much to keep up."

A few news tidbits came on Alumni Fund envelopes. Dr. **Charles Scranton** reports his retirement from the practice of medicine. "I'm 83 years old and getting feeble." . . . **Phil Payson** of Fort Myers, Fla., writes, "Marion and I are both well and I play golf every week. Last May our daughter Beverly received her master's degree at C.W. Post College. Grandson Kevin McNally graduated from Emerson last June and we were there." . . . **Bob Worsencroft** says, "Just a line to let you know I'm alive and kicking out here in Sun City, Ariz. My activities have been somewhat curtailed the last five years since my wife is confined to a wheelchair. However, I keep busy with my hobbies and a few club memberships. Would like

Frederick H. Norton Moves from Ceramics to Forestry in Gloucester

Remember **Frederick H. Norton, '18**? Lots of alumni do, for he taught physics for eight years starting in 1923 and then metallurgy for 30 years before retiring in 1962.

Wendy Quinones of the *Gloucester Daily Times* found Professor Norton late last summer, cutting trees and tending paths on more than 100 acres of manicured woodland and meadow surrounding his 1728 farmhouse on the edge of Dogtown, the barren center of Cape Ann.

"I guess I've planted about 100,000 trees here," Professor Norton told her — and most of them were raised from seed. When he first bought the land there was heavy work to do — building fire trails, planting trees by the thousands. Now, Professor Norton said, clearing and maintenance are easier. The last trees were planted ten years ago. So there's more time for enjoying the friuts of the labor, including some 100 bird species who visit during the year.

Others are less reticent than he to describe Professor Norton's achievement. "It's extraordinary," Hugh Putnam, a forester for the New England Forestry Foundation, told Ms. Quinones. "He has taken bare rocks — just a rotten, rotten area — and made a series of beautiful plantations. In an aerial photograph, you can pick up his land right out from its surroundings; [he's] gone way beyond what anybody else would have done."

to attend our 60th but am afraid I won't make it."

George Schnitzler writes, "This past August Anne and I took a 14 day cruise along the western coast of Canada and Alaska. The highlight was a visit to the Glacier Bay area. Spectacular! Unforgettable! We are both looking forward to our 60th Reunion."

Laurence Buckner is still very alert mentally even though he was hospitalized last year with heart trouble. After the chairman of Columbia Gas Co. predicted a considerable rise in the cost of all fuels in the next five years, Larry prepared an analysis of the cost of heating with various fuels. He concludes that even though fuels will remain competitive, more and more people are going to demand electric power for space heating.

That's the news this month. If you'd like more news, write us. — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, NJ 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, FL 33579; **Samuel E. Lunden**, Assistant Secretary, 606 S. Olive St., No. 701, Los Angeles, CA 900

22

We hope to get additional news from those of you attending the inauguration on September 25. **Earl H. (Buck) Eacker** writes about meeting mutual friends from Buffalo way up on the coast and about moving back to Boston from Annisquam. These summer places cause frequent trips and periodic inconvenience but are enjoyable. Buck tells of **Yardley Chittick** and **Ab Johnson** coming over from Ossipee for lunch. . . . Your secretary found a good many friends and M.I.T. alumni but no classmates during an electrical meeting in New Orleans in October. We enjoyed the Plimsol Club, Al Hirt, and Pete Fountain's music, and the food and dancing.

A note from **Theodore P. Shlikoff** of Guntersville, Ala., says that he is 93 years old and in good health, so take encouragement for your future. Ted states that he has difficulty walking but enjoys watching TV and following the Cincinnati Reds. He is living with Henry Moshkoff and hoping for visits from classmates. . . . **Charles C. Bray** is living near Chicago and has fond memories of the new M.I.T. buildings on the Charles River. His graduation was delayed during service in France during World War I.

Edward J. O'Connor of North Andover is reducing his business activities to favor more time at the Andover Country Club with the "Geritol set." He still shoots his age about once a year and hopes to get better in golf as next season comes along. . . . **Vernon Whitman** of Pomona, Calif., forwarded a delightful and witty birthday card to the Fergusons in October with good wishes for our February cruise on the *Vollendam* through the Caribbean. Perhaps Dorothy and her cabinmate will find classmates aboard as we leave Miami. We will still be working on our year-round Christmas plan — making monthly payments toward the 60th. . . . Still being reviewed is the itinerary of Madeline and **Parke Appel** and their marvelous description of the September trip to the inauguration. It was so thrilling that we are tempted to publish the entire mile-by-mile description — 3,588 miles in their yellow "Pajamas" Cadillac. Parke again repeats that he would like suggestions for plans of our 60th Reunion in June of 1982. He says, "Be a beaver, give a damn."

We are sorry to have lost our member, Dr. **Leo H. Shedlovsky** of New York City. Our sympathy goes to his family.

An invitation has arrived for the M.I.T. Fiesta near Mexico City in March with a very attractive program on a most reasonable basis. Perhaps we could assemble there for our next reunion. . . . And now we part with sorrow and hope singing our usual refrain requesting that you write more frequent and funnier news to your secretary. — **Whitworth Ferguson**, 333 Ellicott St., Buffalo, NY 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, FL 33060

23

Tom Drew, **Ned Frank**, **Julius Stratton**, **Bert Warren**, and **Dick Frazier** attended the fall luncheon meeting of the emeriti on November 13. Others of our class on the Institute staff were the late **Bob Hershey** and**Bernie Proctor**, and emeritus **Bill Allis**, making a total of eight.

Frank Dillon died September 22, 1980, in Malden, Mass. He graduated in mechanical engineering with our class. After graduation he worked for the General Electric Co. in Lynn until 1930. He then taught mechanical engineering at the Bradford Durfee College of Engineering for 34 years, retiring as chairman of the department in 1964. In 1941 he served on the Massachusetts Teachers Federation committee for professional standards. He was a World War I veteran, a member of the Massachusetts Society for Mechanical Engineers, and of the Massachusetts School Masters Club.

Paul Plant died on November 10, 1980, in Lincoln, Mass. He graduated with our class in electrical engineering. After graduation he worked for General Electric Co., the New York Central Railroad, the Hartford Steam Boiler Inspection and Insurance Co., and finally for many years for Stone and Webster as a power engineer. He supervised the initial operation of turbine generators, steam generators, and power plant auxiliaries, and consulted on the engineering and designs of new power plant installations, engineering studies and reports. During World War II he served as lieutenant, U.S. Naval Reserve, retiring as commander in 1945. He served also as superintendent of the Naval Training School at the Philadelphia Naval Shipyard. He was a member of the American Society of Mechanical Engineers, Institute of Electrical and Electronic Engineers, and National Society of Professional Engineers. He had an absorbing interest in music and was an accomplished organist. He was the second roommate to be lost within a period of a few weeks by your secretary/treasurer. — **Richard H. Frazier**, Secretary, 7 Summit Ave., Winchester, MA 01890

24

In the form of a medal, certificate, and honorarium, Professor **Hoyt C. Hottel** has received the highest award that the National Academy of Engineering Founders can bestow. The academy cited Professor Hottel for outstanding contributions to radiative heat transfer, combustion, and energy conversion, ranging from fuel-fired boilers, internal combustion engines, and solar heating to glass manufacture and firefighting. He has received numerous other distinguished awards from both the United States and British governments.

Raymond L. Bowles passed away April 9, 1980, in Lancaster, Penn. He gained his S.B. in engineering administration. He became an executive and apparently retired from Armstrong Cork Co. in Lancaster. In 1918 he was in the Coast Artillery. He attended the Summer Surveying Camp in East Machias during 1922. During the Labor Day competition for all-around athlete his fast crawl stroke placed him far ahead in the swimming event but not enough for his name on the Field Day Cup.

The Fearless Four, **Ray Lehrer**, **Herb Stewart**, **Don Moore** and **Russ Ambach**, were guests of Ray at the Algonquin Club on November 10. Class finances and the 1981 mini-reunion were discussed, the chief question being the individual amount necessary to hold reservations and pay for pre-reunion expenses. The consensus was that an individual deposit should be large enough to cover all but room expense, any surplus going into the class fund. This would eliminate complicated bookkeeping and refunds. — Co-secretaries: **Russell W. Ambach**, 210 St. Paul St., Brookline, MA 02146 and **Herbert R. Stewart**, 8 Pilgrim Rd., Waban, MA 02168

25

The class was well represented at the October 1980 meeting of the Alumni Council. It was on this occasion that **Jim Howard** was actually presented the Harold E. Lobdell Distinguished Service Award. **Will Gardner**, **Courtenay Worthington**, **Sam Spiker**, and yours truly also attended this largest council meeting in history.

A copy of a letter written by **John Campbell** to Robert H. Bliss, '48, a district officer in the M.I.T. Leadership Campaign has reached me via the Alumni Office and John has given me permission to quote from it. He was thanking Bob Bliss for delivering a copy of the inauguration program to him. Having read with considerable interest John's recollections, I feel all classmates should hear them, in his own words, which read as follows: "The Lord must have had you by the hand when some inner voice impelled you to take this trouble. Looking over this program with all its pomp and ceremony brought memories back to me that you could not have anticipated. In 1916, over 60 years ago, my father took me, as a teenage youth 13 years old, down to Cambridge to see the exercises in connection with moving M.I.T. from Boston to Cambridge. I still recall the excitement, the bands playing and the students dressed in military uniforms, some of them older boys that I knew from my home town of Arlington.

"Although little did I know it at the time, but I am sure of it now, my father must have had hopes that my experience of participation in this event might motivate me to get pointed toward M.I.T. He, himself had grown up in the poorer section of East Cambridge between Kendall and Central Squares. So you see I have my roots deep in M.I.T.

"My father lived to see the innoculation take I am glad to say. While I was in high school I used to go down to M.I.T. on the street car and, passing myself off as a student, I used to browse around the library stacks under the Dome reading scientific books. Talk about getting a young man motivated. I breezed through Arlington High and was class valedictorian. But when I got into M.I.T. I was in a different element. All were class valedictorians. But it was wonderful and I enjoyed every minute of it."

George Washington reports that he was a delegate to the inauguration of Paul E. Gray as 14th president of M.I.T. He was the representative of Tuskegee Institute where he had served under the last three presidents of that Institute from 1933 to 1949. Tuskegee has had only four presidents over its first hundred years.

A note from **William Muschenheim** indicates that his book, *Why Architecture?*, was published by the Karoma Press, Ann Arbor, Mich., in 1980. — **F. Leroy (Doc) Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

26 55th Reunion

In late October **Bob Dawes** and your secretary had the pleasure of a visit to Pigeon Cove with our wives where we were graciously entertained at lunch by **Ruth Smith**. It's been a little more than a year since Smitty's services were held in Rockport, and Ruth spoke of his classmates who had attended as well as others who had written to express their sympathy. Ruth continues her interest and aid to M.I.T. as George did so generously with his time and resources. It was a cool clear autumn day, and as we looked out over the ocean from the magnificent vantage point, we wereremінded of his observations in the Notes for the *Review*.

On October 27 we attended the first full committee meeting for the 55th Reunion. **Don Cunningham**, **Bob Dawes**, and **Joe Levis** attended, and we were assisted by Frances Bangs of the Alumni Office in preparing the publicity. By now you will already have received the first notice, so it will be unnecessary for us to

elaborate on the program except to say that with Joe's help we expect to have an excellent sports and entertainment program including a showing of the finished product of George Smith's work on the videotape of the 50th.

Pink Salmon has moved to Pennswood Village H114, Newtown, PA 18940 and was unable to make our committee meeting but will continue participating as class treasurer in reunion planning. He writes telling of his new residence in a development under the aegis of the Philadelphia Meeting of Friends. He and Mary seem to be well established in their new community. Pink is already a director and treasurer of the Residents Association, and Mary is involved with the Social Services Committee. The move to Pennsylvania was the result of his giving up his full-time activities and the fact that they had no family in the area. Their son Billy lives in Washington and Bojey in Minneapolis, while Mary has cousins in Bethlehem and Harrisburg. There are apparently a number of well-known former educators among their neighbors as well as Bernie Morgan who was in Course XV with Pink for most of the four years.

Jim Killian sent a copy of the Draper Lab Notes in which was an article describing **Doc Draper**'s recent trip around the world. A note from **Phil Robinson**; "Retired for 19 years. Working as a consultant — rebuilding a roof tile plant, redesigning furnaces, building a new batch plant, and changing a plant layout. Various other activities include reducing 'acid rain,' etc." A pretty active retirement, Phil!

A letter from Sally MacDonald tells of the passing of her husband **Roger MacDonald** on October 7, 1980, at his home in Woodstock, Conn., after retiring from Koppers Co. He traveled much and had a happy country life with Grange activites. They enjoyed visits of their two daughters, three grandchildren, and lately three great granddaughters. — **William Meehan**, Acting Secretary, 191 Dorset Rd., Waban MA 02168

28

In early September Florence and I began our annual end-of-the-summer automobile trip through New England. It was terminated abruptly because of a family emergency. In early November we resumed our trip — mostly through the western part of Maine, and this gave an opportunity to visit with classmates in that area. We had a pleasant stop in Fryeburg, Maine, with Priscilla and **Roger Haven**. Roger is busy as ever working on home projects. His latest accomplishment is a home protective alarm system which is actuated even by an attempt to remove the weathervane from the top of his house. The Havens appear to be in very good health. Roger would like to find someone to join him for iceboating. Do any of you qualify?

Also in Fryeburg we enjoyed the hospitality of Sue and **Jim Tully** in their beautiful and historically interesting old house (early 19th century). At the time of our visit they were considering going south to Florida for the winter. We stopped in Raymond, Maine, for an enjoyable afternoon with Louise and **Ernie Knight**. Their home is located on the shore of Panther Pond (it is really a lake) and surrounded by woodland which Ernie owns and maintains as a managed forest. Needless to say, they have plenty of firewood and this provides lots of exercise. From Ernie we learned that water from Panther Pond flows through a waterway into Lake Sebago. In the spawning season landlocked salmon from Sebago ascend this waterway where a predetermined number of them are trapped and stripped of their eggs and milt. These are taken to a hatchery to produce fry which later, as fingerlings or yearlings, are used not only to restock the local lakes but for supply stock to all parts of the world. ('28 fishermen take note!)

We are pleased to have a good lively letter from Frances (Mrs. **Carl F.**) **Myers**. She is in good health and very active. In 1979 she spent two months in Holland and France. This year she is president of her garden club.

Alumni Fund news panels have provided the following news. **John Houpis**, reporting from Greece, says that he has moved from Corinth to Athens where he is living with his son George and family. John, who celebrated his 83rd birthday on August 3, 1980, is feeling fine and would like to meet any '28ers who might be passing through or visiting in Athens. . . . From **Fritz Rutherford**: "Still living in the deep South. I took an air, motor coach, and cruise trip through Alaska, Yukon territory, and the Coastal Inner Passage back to Vancouver, Canada. Our last frontier is gorgeous country. July is the best time for this trip." . . . In answer to the question on his activities, **Howard Root** modestly replies: "It would take an EFG to detect any activity in this old boy."

A telethon was held for our class at M.I.T. on October 30, 1980. Those on hand to do the calling were Frannie and **Jim Donovan**, Ann and **Will Tibbetts**, Ruth and **Abe Woolf**, and Florence and **Walter Smith**. We were able to reach many of you and enjoyed the opportunity to chat briefly. The gracious response from so many of you was much appreciated.

We regret to report at this time that **William E. Gould** died on April 9, 1977. This information has only now come to our attention. Bill studied in Course XV, business and engineering administration. He had his own insurance business in Providence, R.I., for 40 years prior to retirement. To his family we extend our sincere sympathy. — **Walter J. Smith**, Secretary, 37 Dix Street, Winchester, MA 01890

29

Thomas W. McCue of Newton Highlands, Mass., is still carrying on his diversified business enterprises — buying and selling steel and other metals. He is also taking business administration courses at Boston University, including courses in conversational Spanish and Portuguese. He sends his best regards to all his classmates. . . . **Henry S. Muller** of Belmont, Ohio, states that he is in close contact with the medical profession to slow down the process of aging. His hobbies are gardening and travel. He and his wife Natalie are planning a visit to Texas and Mexico to escape the snow and cold winter in the hills of Belmont.

Stephen N. Dilworth of Largo, Fla., sends a note: "I read the report of your operation last July, and I am glad it was a successful one and that you are back to normal. We spent the hot summer in Largo. We took a cruise in the spring to the Central American countries and spent some time on Sanibel Island. While there, my wife Myn bought some interval ownership on the Gulf side, and when we went down again in late summer, I bought some time on another location. So, we will be spending some time in our ownership accomodations, unless we exchange them for other locations through the Resorts International. I enjoyed reading about **Earl Erickson**, who was at the 50th Reunion with his wife Marion. He was my fraternity brother during our undergraduate days, and we wrote our thesis together. It was a great joy to renew our friendship after a half century. Best wishes to our classmates."

My neighbor **Bill Slagle** sends a note, "Thanks for remembering my birthday. Your 'tickle' file is right on schedule. Why in the world do you want to leave this beautiful spot on the hill? When you get back from New Hampshire, you and your wife have got to come down and have a drink with us." . . . **Marshall David** sends his regards to all '29ers, especially **Jim Fahey** and **Frank Mead**. . . . I have a note from **Frederic Celler** of France and Maitland, Fla., as follows, "I have just had my annual physical, which shows that I am in good shape, followed by my 72nd birthday celebration, followed by a notice from the social security office that I will shortly be receivcg a monthly check. We are about ready to pack up our suitcases and return to our Florida home for the next seven months. Our stay in France for five months has been as satisfactory as ever. I would like to extend an invitation to any of our classmates who happen to be in Paris during the summer to play golf with me at Saint Cloud (I have an extra set of clubs). Au revoir until next year." Fred is truly an ambassador at large for Franco-American relations. He has divided his love and devotion between his native country (France) and adopted country (U.S.A.), and has done much to foster good relationships between the two. He was, prior to his retirement, president of AMP de France, subsidiary of AMP, Inc. He was active in the Franco-American Chamber of Commerce of Paris for a good many years as director and president for a period. He lists his hobbies as golf, gastronomy, and history.

Eric A. Bianchi of Tequestra, Fla., writes, "Kay and I spent a week in early August at Bold Peak Colony Club and had a fine visit with **Wally Gale** and his wife Joan. We also enjoyed some cool New England weather which was a welcome change. Kay is recovering well after a cataract removal and an implant. She is looking forward to her freedom when she can again drive her car. I had lunch with **Hugh Hamilton** and **Gus Stein** in July at Broken Sound Club in BocaRaton. It was great to see them both and we are saddened by Hugh's recent death. Our very best wishes to all." Most of Eric's professional career has been in the general management field as director of engineering, vice-president, and later president of Masoneilan of Norwood, Mass. In later years, he was director of planning at Studebaker-Worthington, president and chairman of the Fluid Controls Institute, and chairman, PMC Section, SAMA. The Bianchis have made Tequesta, Fla., their permanent residence.

Phil W. Sayles of Lakeville, Conn., writes, "Upon reaching age 74, my daughter sent me a wired message, 'Congratulations on reaching the threshold of three quarters of a century.' I have been in and out of two hospitals for the past three months, the first hospital visits since I was 16. I am fine now but no golf yet; I hope soon though. I have been a Rotary Club member for about a year, helping groups and individuals. I went to a party recently and asked three men where they went to college, as a matter of conversation. The answer came, 'Yale — Yale — Yale.' One of the men asked me where I went, and I said, 'University of Illinois, science.' Then I added, 'Would it make you feel any better if I said I took my master's from M.I.T.?' One of the men answered quickly, 'Yes, it's farther east.' "

Recently, I received a note from the widow of **T. Bailey Curran** informing me that her husband passed away on September 21, 1980. At the time of his death, he lived in Stratford, Conn. He helped develop the atomic bomb, founded Bridgeport Engineering Institute, and served as chairman of the Department of Chemistry and Metallurgy until 1961. In 1975 he was named a fellow of the school. He also worked for Remington Arms for 30 years, retiring in 1974. He is survived by his wife Phyllis, a son, and three daughters.

Barrett L. Weston of Granby Conn., passed away on June 28, 1979. He was an instructor at the University of Hartford for 46 years. . . . **Gus Stein** of Boca Raton, Fla., has sent me a note bearing sad news, "In your birthday note you speak of joining me and **Hugh Hamilton** for our weekly Thursday noon luncheons when you get to Florida. Apparently you haven't heard that Hugh passed away on September 18. I don't know the cause, but I know that several weeks beforehand he had not been eating and was showing less interest in what was going on — something very unusual for him. He may have just gotten tired of his limited existence." Hugh was an active member of the class, and he participated in all of our class activities and reunions. Hugh and Helen were on the 40th Reunion Committee, and they played an important part and contributed much to its success. It was shortly after that reunion that Hugh had his massive stroke in Florida which left him paralyzed from the waist down. This did not break his spirit; he had the will to live, and Helen gave him all the care, devotion, and affection to

make his limited existence more than just tolerable. For many years Mary and **Frank Mead** and Helen and your secretary would visit the Hamiltons at their home in Boca Raton where we were treated with cocktails followed by a dinner at the Royal Yacht Club, which he enjoyed as much as any of us. After graduation, he joined the engineering department of Hygrade Lamp Co. (which later became Sylvania Electric Products). He married Helen Ford-Smith in the fall of 1929, and they had five children and seven grandchildren. In 1935 he joined Bendix Aviation at Eclipse and Pioneer Division. In 1940 he organized a company known as Eastern Air Devices, Inc., manufacturers of aircraft instruments, electric motors and blowers. He moved the company from the New York area to Dover, N.H., in 1953, which proved to be a good decision, as the company prospered, later going public and getting listed on the American Exchange. He sold the company in 1959 and managed it for the new owners until 1962 when he retired. The Hamiltons celebrated their 50th wedding anniversary a few months ago.

Some of you have inquired about where your secretary lives. To set the record straight, our permanent address is in Hampton, N.H., but we spend winters in Fort Lauderdale, Fla., and early springs and late falls in Arlington, Mass. To avoid confusion I am using my business address in Arlington for all correspondence. — **Karnig S. Dinjian**, Secretary, P.O. Box 83, Arlington, MA 02174

30

This month's notes are the first to be written at our new winter home in Green Valley, Ariz. They will be necessarily sparse since the only material at hand is that received before we left Southbury. **Allan Stone** reports from Elkhart Lake, Wis., that he is leading a quiet life trying to recover from a heart attack. He has been helping a neighbor with the maintenance of a collection of antique cars, including a Jaguar, Bentley, Lincoln, Winton, Mercedes, and Ford. **Dave Stanley** has moved to Walnut Creek, Calif., where he has continued to do free-lance research and writing on air transport economics and is active in the local musical society. He reports having recently seen **Morris Shaffer** who, according to my most recent information, is doing administrative work at the Louisiana State University Medical Center.

As previously reported in the Notes, **Bill Spahr** retired several years ago from the Metropolitan Insurance Co., where he was manager of budget and costs. The Spahrs have continued to live in Smithtown, N.Y., where Bill is a member of the Village Planning Board and pursues his hobbies of bowling, golf, and stamp collecting. He reports having received a letter from **Tom MacLaren** who was unable to attend the 50th Reunion because of a conflict with his grandchildren's school graduation functions. — **Gordon K. Lister**, Secretary, 294B Heritage Village, Southbury, CT 06488

31 50th Reunion

Technology Day, a traditional feature of Reunion Week, will be Friday, June 5. This year's program will focus on the automobile. We hope to see you there. I believe by the time these Notes are published you will have received word about the details of our 50th Reunion. If not, please drop a line to one of your class secretaries or to our reunion chairman, **Dave Buchanan**, whose address is Orchard Hill Rd., Peterborough, NH 03458.

Although he didn't give me much information about himself, it was a delight to receive a telephone call from **Fred Stanley**, with whom I wrote my thesis at M.I.T. many years ago. Unfortunately, Fred won't be able to attend our 50th. . . . Talked with **Fred Elser** this evening via ham radio and he reports all well there. . . . **Elliot Whitaker** writes, "Just retired after architectural teaching eleven years at Penn State University, three years at Syracuse University, one year at Middle East Tech (Ankara, Turkey) and thirty years at the Ohio State University." . . . **Bill Hubbard** writes "M.I.T Press published my book, *Complicity of Conviction: Steps Toward an Architecture of Convention*. I was awarded the Alice Sundry Prize, given by the Virginia Society of the American Institute of Architects, for excellence in contract documents."

The alumni of Florida are planning the third in a series of Florida festivals on February 21-22. Further information can be obtained from George H. Wayne, 4280 Galt Ocean Dr., Fort Lauderdale, FL 33308, (305) 565-5410. . . . A note from Tony Savina, '30, tells of **R. Byram Porter, Jr.**'s death on Saturday, October 25. Savina goes on to say "Byde, as he was generally known, was born in Somerville, Mass., on October 28, 1908, and had lived in Darien many years. Before entering M.I.T. he graduated from the Malden, Mass., high school. He is survived by his wife Dorothy, two daughters, and three granddaughters. For several years prior to his death, he was affiliated with Moore and Munger, Inc., Fairfield, Conn., as a development chemist. For the past year he was working for them part time on a consulting basis. He was a member of TAPPI for many years and an active member of its Papermaking Additives Committee." . . . A letter from Laura Damiano, **Fred Damiano**'s wife, tells of his death on October 21, 1980. During his career Fred built bridges, dams, roads, dozens of schools, and many hospitals. He received three E awards for excellence in construction at the Floyd Bennett and LaGuardia Airport during World War II. Fred is survived by his wife Laura, a son Robert, a daughter Mrs. Elaine Sacco, and four grandchildren. . . . Word has also been received of the death of **Leslie Reed** on August 23, 1980. Leslie was a past president of Greenfield Rotary Club and a member of the board of directors of Greenfield Cooperative Bank. He leaves two sisters and four grandchildren. During his career, he handled the engineering and business matters concerning the family construction firm. . . . A note to the Alumni Association from **John Brandli** says, "It is with deep regret and sorrow that I advise you of the death of **Bernard T. Stott** on September 18, 1980, at his home in North Palm Beach, Fla. Bernie had retired from his position as comptroller at Citibank in New York and had left Port Washington, N.Y. to live in North Palm Beach where he could enjoy his golf at Lost Tree Golf Club." . . . Our sincere condolence to their families and friends. — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; Assistant Secretaries: **John R. Swanton**, 27 George St., Newton, MA 02158 and **Ben W. Steverman**, 3 Pawtucket Rd., Plymouth, MA 02360

32

On October 28 I participated in a M.I.T. telethon. This gave me the opportunity to talk to several of our classmates throughout the country. **Albert O'Neill** also participated in the telethon. After a career of teaching at M.I.T. he semi-retired in 1974. He does some consulting work and at present is monitoring an A.I.D. project for Egypt at M.I.T. When time permits he works on his home in Milton, Mass., and he and his wife Helen travel whenever possible.

On the phone I had a good talk with **Christian Grosser**, of Richmond, Va. Since 1961 he has been an engineering consultant in private practice for industry, government, and scientific institutions. He helpfully sent me his resume; he has taught at M.I.T. and Syracuse University as a professor. His specialty is advanced mechanical analysis of machines. His clients are nation-wide, and he often appears in court cases. He and his wife Dorothy have five grown children and five grandchildren.

George Green of Bristol, R.I., is retired and likes to spend his summers oil painting in his cottage in Nova Scotia. George lost his wife Mary nine years ago. . . . **Sidney Friedman** of Springfield, Mass., retired nine years ago; he and his wife Madalyn like to travel in their spare time. They have a son who graduated from M.I.T. and is engaged in chemical work on the West Coast. . . . **Curtis Tucker** of Westport, Conn., worked as a chemist for General Electric. He retired in 1974 and enjoys traveling with his wife Ruth. They visit their three children and four grandchildren.

Kenneth W. Smith writes, "Enjoying retirement but find it difficult to do all that we want because of inflation. Both Betty and I are having fair health and expect to spend the winter in Indian Rocks Beach on the Gulf in Florida, as usual.

In September we had a good time with Allison R. Dorman, '33, and wife Anne in Greenfield, Mass. Hadn't seen him for 40 years. We were roommates at Phi Epsilon Kappa and found lots to talk about. All for now. — **Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, MA

33

We assume that you read the story of the awards in the November issue, and please allow me to state that I am duly appreciative of the honor. May I enlarge a trifle so that you will know how this is done? The Harold E. Lobdell Award was presented to five of us at the Alumni Council meeting (the largest ever) on October 27 in the large dining room of the Stratton Student Center. I received a letter from **Ellis Littmann** on October 15 urging me to announce my part of the awards for the January issue. Inasmuch as I had not then received the award, I refused to publicize it. The award committee suggested that each recipient of the Lobdell Award be accompanied by his spouse, a member of his family, or a guest. I chose my grandson, Warren Charles Henderson, of Tallahassee, Fla. We sat with **Westy Westaway** and **Chuck Fulkerson**.

We have a few Alumni Fund capsules which are always welcome. **Peter Parker** writes that he is keeping busy in retirement remodeling an old house. He is the church moderator, secretary of a non-profit housing corporation, and serves on the Town Conservation Committee and the Town Budget Committee. . . . **Edward Kimbark** writes that in February 1980 he was awarded the William Martin Habirshaw Medal by the IEEE for "meritorious achievement in the field of electrical transmission and distribution." The award was accompanied by a $1,000 check. . . . We have a rather long, typed capsule from the Reverend Winthrop E. Robinson '32, who spent 45 years of active service as a missionary in India and as a pastor in four states from Maine to Minnesota. Though now retired, he is still serving churches where an interim pastor is needed. "I find that the years at M.I.T. were a good foundation for effective ministry of the gospel of Jesus Christ." Thanks a million, Win.

Dick Morse is still director and advisor of several high technology companies in the Boston 128 group, as well as a member of the executive committee of Dresser Industries in Dallas, which keeps him busy. The Morses have recently bought a place in Delray Beach, Fla., so will winter there and summer on the Cape. My daughter, Phyllis Carey, lives in Delray Beach most of the year, so we will allow nature to take its course. . . . **John MacIsaac** writes briefly about his new address in Titusville, Fla. John says he is finally getting his health back after a rough hospital bout in February. He says it is sure tough to get old.

We have two deaths in the ranks. **Benjamin F. Sands** of Nashua, N.H., passed away September 15, 1980. Ben was a Course XV student but left us early, as too many did at the time. He prepared at Williston Academy for M.I.T. He was very active in business all his life, mostly with his own firm, Lewis and Co. He was also active in several business organizations and held office in most of them. He was a former North Reading resident and served nine years as selectman. He was a member of the Lions Club and the Masons. I will write Mrs. Sands on behalf of our class. The other is belated word of the death of **John K. Campbell** several years ago. That's it for now. With best

regards. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H, Exeter, NH 03833

34

This month's notes are all courtesy of responses that accompanied Alumni Fund contributions. So I want to thank you for both. As is so often the case, some are really on the brief side, and I think this one makes a good starter. **Aldo Minotti** simply says, "I am still in the practice of architecture."

One of the local boys seems to be wandering a bit. **Tom LaCava** writes, "Still working with the state of New Hampshire — get to the Cape as often as I can. Expect to fully retire when inflation stops." I think Tom has to lower his sights some or he'll be working forever. This is written in November, after the election, and I'm not too sure the winners know how to bring that miracle to pass!

From an old friend, **Bill Schumacher**, comes, "Awaiting second grandchild via son (Walter) and his wife (Valerie). Walter is also pursuing a law degree at the University of Pennsylvania (1981) and will join Morgan, Lewis, and Bochius of Philadelphia. Daughter Mary married Peter Gilbertson Barno July 26, 1980, and they are residing in Concord. Both are graduates of Dickenson College, 1975."

One from **Adolph Warsher** is a little puzzling. He signs it as " '32," but the Alumni Register shows him as a member of our class. Anyhow we can share his news with all. He says, "Since 1973 have been a staff engineer at the C.S. Draper Laboratory. Prior to this I served as plant engineer with GMAD at Framingham. I also was associated for 15 years with Bendix Corp. at Teterboro, N.J., where I rose to be manager of reliability control engineering and standards. Currently, I am immersed in research and development efforts for a new round of navy ballistic missile guidance systems.

Finally, **Wolfgang Rahles** writes, "Retired, but still consulting for Ashland Chemical. Not strenuously, as I spend four months in northern Michigan, the remainder mostly in Columbus, Ohio."

We're scheduled to begin a 12-day Caribbean cruise on February 22, a good time to abandon New England for a few days. This replaces the one we had to cancel when I was stupid enough to land in the hospital January 2 of last year. So from this writing until then, I have my fingers crossed. — **Robert M. Franklin**, Secretary, 620 Satucket Rd. (P.O. Box 1147), Brewster, MA 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20015

35

Jack Colby writes that the autographed card we sent from our reunion gave him a big lift just when he needed it and sends his sincere thanks to all. He is rapidly recovering from a quintuple bypass operation and doing lots of walking because he feels so good. . . . **Jack Holley** writes via the Alumni Office that he and his wife are in good health. His health is so good he wore out his 15-year-old grandson. He keeps busy between gardening and gold prospecting (that's easier done in San Diego area), and expects to go to school this fall and take a course in mineralogy! . . . **Samuel Paul** announces that his son, David J., who joined the company in 1963, has moved up to the masthead. The company's name is now Samuel Paul and David J. Paul, Architects. . . . **Hugh L. McMath** received his master's with us after getting his B.S. in architecture from North Dakota State in 1927. He's proud of the fact that his master's thesis together with some of his drawings are on display in M.I.T.'s Historical Collections. He is professor emeritus at the University of Texas in Austin, where he has been since 1930, excepting the war years, until he retired in 1974. Since then he and his wife have traveled the world — you name it, he has been there! He expected to be visiting New England in October 1980.

Mort Rosenbaum and his wife Lorraine took a five-week Iberian trip starting October 3. . . . **Bissell Alderman** writes: "Have just been re-elected president of the Sharon, N.H., Arts Center on Route 123 near Peterborough. It is somewhat M.I.T. oriented — Sam Spiker, '25, Jim Killian, '26, Tom Rhines, '32, and Len Krause, '39, all board members. Also got elected chairman of the board of deacons at my church and to the board of the Thorndike Club. Retirement, what is it?" . . . **Art Haskins** writes from Bath, Maine, "Now that I am retired, I find there is a built-in inertia to complete the list of things that 'I'll do after I retire.' Just finished installing a wood-burning warm air furnace to reduce oil consumption. Raced a full schedule in my Morgan 27 Starfire and managed to stay in the upper 20 percent. Now tackling my list." . . . Congratulations go to **Dick Shaw** who won the 20th Annual Class Golf Championship. Dick beat out **Bill Cross** who had to play in wintry weather in Minnesota. This was the first year both Consolation Flight Winners ended up in the finals. **Al Johnson** and **Dick Bailey** won the flights, and each lost to the finalists by 0.4 stroke! Incidentally, I made a grave omission in the reunion report: Dick Shaw played with **Goffe Benson** at Wianno in the rain "and finished the nine holes together underwater."

Florida alumni are planning the Third Annual Florida Festival for February 21-22 at Cypress Gardens. For details contact Carol Seligson, '71, M.I.T. Alumni Association, Room 10-123, Cambridge, MA 02139.

Wesley H. Loomis III, retired president of the General Telephone Directory Co., has been selected for the Illinois Business Hall of Fame. Congratulations, Wes. . . . **Hal Bemis** writes that his youngest daughter was admitted to Houston Medical Center this fall to learn to be a doctor in four years. We wish her well, and you, too, Hal! . . . **Clarence Goldthwaite** retired to a quiet life on the Cape in 1974. . . . **Vincent Sorrentino** lost his sight completely in January 1978. With the help of the Massachusetts Commission for the Blind, Vince has been receiving magazines on plastic records. Perkins Institute lends him stories, etc., on cassettes that he plays on his tape machine. He is in good spirits and asked about many of you when I talked to him by M.I.T. Telethon October 29. I am sure he would enjoy hearing from any of you who knew him (or even if you didn't know him) from the Course XV days. Give him a call. His phone number is (617) 369-2293, and he lives in Concord where his wife is taking care of him.

I apologize for missing my deadline for the last issue and leaving 1935 a blank in the Notes for January. I was going through a bunch of tests which ended up with some very minor surgery on both my knees November 13 and honestly forgot the need to get the Notes typed until ten days later. I'm really O.K. and am sure I will be back on the course next spring with the good progress I am making. I have letters from **Ned Collins**, **Les Brooks**, and **Bill Parker** to pass along in the April Notes plus tidbits from telethon conversations with eight more. In case you are so inclined, my next deadline is March 3. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, MA

36 45th Reunion

Retirement news continues to come in but so does information about transfers and changes of position from those still gainfully employed. **George Trimble** retired in October as president and chief executive of Bunker Ramo Corp. in Oak Brook, Ill. No further information as to his plans is available now. . . . **Ariel Thomas** has moved to Atlanta as AAT Manager, Southeast Region for Metcalf and Eddy, Inc. Avis and Ariel are living at 1593 Howell Highlands, Stone Mountain, GA 30087. . . . **Mac Nyhen** reports from Arlington, Vir., that he has been thirty years in Washington and nearly that long with the Commerce Department where his concern has been with the electronic and telecommunications industries. He expects to stay there for a while. His daughter is in her senior year at Barnard and his son "still has some work to complete at George Washington."

Another busy one is **Dorian Shainin** whose consulting takes him far afield. Accompanied by Margaret he was in Israel and Belgium last fall and followed work with some vacation time in the U.K. and Ireland. . . . **J.F. "Pat" Patterson** is in his 45th year with the Linde Division of Union Carbide in the financial control area. He suspects he may retire "someday." Pat and Marian with daughter Marcia spent a most interesting vacation in Iceland last summer. . . . Catherine and **Gerry McMahon** spent over four months in Europe, making their headquarters with a daughter and son-in-law in Germany and taking advantage of the many bus tours available to the American military community. Now they are back in Lake Charles, La., and hope to make the reunion in June.

October 25 found 28 of us together for dinner here in spite of terrible weather. It was a fun party and I hope everyone else had as good a time as I did. The guests were: Mary and **Fred Assmann** from Pennington, N.J.; Edith and **Gerry Chapman** from Stockbridge, Mass.; Virginia and **Dick Denton** from Marlton, N.J.; Vivienne and **Eli Grossman**, Farmington, Ct.; Rilla and **Walt MacAdam**, Hanover, N.H.; Virginia and **Augie Mackro**, Monroe, Ct.; Marian, Marsha and **Pat Patterson** from Pleasantville, N.Y.; Lillian and **Larry Peterson**, Schenectady, N.Y.; Phoebe and **Frank Phillips** from Brownsville, Vt.; Ruth and **Bob Sherman**, Warwick, R.I.; Peg and **Fletch Thornton** from New London, N.H.; Edith and **Ang Tremaglio** from nearby Waterbury, Ct.; and **Bernard Vonnegut** from Albany, N.Y. There were several first timers as well as many "old faithfuls." Those of you who had responded to the invitation were noted and missed. We hope to see you all in June at our 45th! — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, CT 06091

37

Henry Blackstone of Laurel Hollow, N.Y., writes that he is founder and president of Servo Corp. of America, president of Servo International Sales Corp., president of Servo Electronic Switch and Signal Corp., president of Electro Pulse, Inc., president of Railway Systems Suppliers, Inc., and on the board of governors of Railway Progress Institute. **John C. Gibbs**, executive vice-president of Nevada Power Co. has been elected to the board of directors of E.C. Ernst, Inc., of Washington, D.C., an electrical construction company.

John H. Fellouris of New Bedford, Mass., is chairman of the board of John H. Fellouris, Inc., General Contractor. On January 1, 1980, he became a life member of ASCE. He belongs to the Wamsutta Club and the New Bedford Country Club and travels to Greece a couple of times a year. John writes, "I elevated myself to chairman of the board of directors and thus have more time to myself for travel, etc. My No. 1 daughter Mercer received her master's degree in business administration and is teaching at Bristol Community College. No. 2 daughter Nikki just entered N.Y.U. for her master's degree in business administration. No. 3 daughter Mara graduated from Mount Holyoke in May 1980, joined the Peace Corps in June, and is now teaching English to the French-speaking natives at Magaria, Niger, of all places. The youngest daughter (No. 4) Harriet is a senior at New Bedford High School and will enter college next September. I have no retirement plans as you can see — I couldn't afford it even if I wanted to! Fortunately, I'm not getting older."

George A. Randall writes, "My new address is 39 Summit Place, Newburyport, MA 01950, and the phone is 617-462-6124. I retired from the Badger Co., Cambridge, Mass. I have traveled to the far east and also to Alaska. My wife's interests are square dancing and movie making. My hobbies are square dancing and duplicate bridge.

After a reception in his honor before the dinner, Philip H. Peters, '37, was the center of attention at the November meeting of the Alumni Council. It was the month of his retirement after 42 years of service with John Hancock Mutual Life Insurance Co. in the group insurance field.

Plaudits to Philip H. Peters, '37, on His Retirement at Hancock

When **Philip H. Peters, '37**, joined the John Hancock Mutual Life Insurance Co. in 1938, fresh from an intensive year of work for a master's degree in M.I.T.'s Department of Business and Engineering Administration, something less than $600 million of group life insurance was in force. By November, 1980, when Mr. Peters retired as Hancock's executive vice-president of group operations, that figure was up to $80 billion.

"We've been in the right place at the right time with the right products," Mr. Peters admitted to J. E. Briand, editor of *Quill*, Hancock's group "house organ." But he added a modest footnote: in such a competitive business, "it's hard to conceive that any company can successfully average much better than the middle of the competitive range"; so what the statistics really reveal is the growth of the group life insurance concept.

Not quite, said Hancock's Board of Directors in a resolution to Mr. Peters on his retirement: "Few have set higher standards for themselves in both corporate and public life. Whatever the task, he has always believed that no opportunity is foreclosed until every access has been exploited to open it up. In the words of his colleagues," said the resolution, "Mr. Peters 'has a tremendous determination to reach objectives and an intelligent, analytical approach to solving problems along the way.' "

The some characteristics have been obvious in Mr. Peters' 43 years of service to his *alma mater* — a record of contributions matched by few alumni in the Instutute's 120 years. At his 20th reunion Mr. Peters was elected president of his class, and 12 years later he became 76th president of the Alumni Association. In the meantime he had established himself as one of the most successful fund-raisers in the alumni body as chairman of the Institute's centennial capital fund program, the Second Century Fund; and he had been selected for the Bronze Beaver in 1964.

Since then Mr. Peters' services to his *alma mater* have proliferated: chairman of his 40th reunion, member of the M.I.T. Corporation (1970-75), life member of the Alumni Council, chairman of the Alumni Association's finance committee (1974), member of several Corporation visiting committees, member of the National Sponsoring Committee for the Building 10 Fund, Alumni Fund major gifts solicitor . . .

A letter from Henry Ford II, quoted by Hancock's Resolutions Committee, speaks for most of Mr. Peters' friends: "You have my personal appreciation for your creativity and efforts over these many years, and I wish you a long and happy retirement.

We have six grandchildren and have just moved from a 12-room house to a seven-room and now plan to square dance on the weekends and travel late in the winter." — **Lester Klashman**, Assistant Secretary, 198 Maple St., Malden, MA 02148; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

38

Bill Guindon sent in his annual note: he is active in the North American Academy of Ecumenists, and will co-chair the IXth International Congress of Jesuit Ecumenists.

Nick Barbarossa, in semi-retirement, continues to work as a consultant with the U.S. Water Resources Council on national and regional water assessments. Of particular interest, he says, is the oil shale program for the DOE, for which water assessments must be prepared before federal financial assistance can be given.

I received a note from **Norm Leventhal**, telling us that **Tom Garber** has passed away. From his wife Selma, we received the following details. "Fondly remembered as 'TGY' by his ham radio friends, Tom Garber became a silent key on Thursday, November 6, 1980, at Emerson Hospital, Concord, after a 17-month battle with cancer. In 1978, Tom founded the Acton-Boxborough Amateur Radio Club, one of many community endeavors which came into being because of his drive and determination. When illness forced him onto medical disability from his position as developmental engineer with Hewlett-Packard Co., of Andover in the summer of 1979, Tom looked for ways to use his time and limited energy as meaningfully as possible. He became deeply involved in community and school activities, forming and teaching ham radio and chess clubs, planning a computer course for adult education, and tutoring junior high school students in math. This past May he received a Massachusetts realtor's license and worked part-time in that capacity for a short while. A neighbor described Tom as 'a sensitive, kind and deeply feeling human being . . . I observed his long struggle against illness with admiration.' His warmth, wit and great inner strength were a source of inspiration to all who knew him. Tom will be greatly missed by his wife, Selma, and his four sons, Philip, 22, David, 20, Jonathan, 19, and Ethan, 13. He also leaves two sisters, Esther Garber (of Brookline) and Rose Klein (of the Bronx)." From the class we would like to express our condolence to Tom's wife and family.

On a more cheerful note, **Dave Wadleigh** informs me that we have a definite date for our annual class dinner on Technology Day at Endicott House. As those of you who have been there know, it is a super place with a super class. Mark it on your 1981 calendar. — **A. L. Bruneau, Jr.**, Secretary, 663 Riverview Dr., Chatham, MA 02633

39

Fred Schaller and Anne retired and live in Wellesley. Fred, treasurer of our 40th Reunion, writes: "The final accounting of our 40th Reunion showed a healthy cash balance. The amount of $850 was deposited in an interest-bearing account for use toward 45th Reunion expenses; $2090.48 remained and was given to the Alumni Fund, designated for the class of 1939 scholarship fund. As Class Agent, I wish to express my gratitude for the enthusiastic and whole-hearted support of all our classmates."

Paul E. Johnson, regional director of the Alumni Association, writes to Mr. Schaller and members of the Class of 1939: "On behalf of the M.I.T. Alumni Fund, I thank you for your generous gift. Your contribution will help sustain superior educational and research activities for which the Institute has been recognized for generations."

Hewitt Phillips retired from NASA at Langley Field, Vir., but continues in the position of distin-

guished research associate. His latest technical paper is an analysis of solar-powered aircraft. Hewett and Viola vacationed in England last summer and made side trips to the Netherlands and France.

Leo Kiley retired from General Electric Co. Leo and Luna moved from Florica to Santa Fe, N.M., where Leo enjoys part-time assignments in corporate planning with Los Alamos Technical Association, Inc., an engineering consultant group. . . . **Joe Weston** has joined other classmates who have retired to Cape Cod. . . . **Bob Pratt** divides his retirement activities on Cape Cod between arranging programs for the M.I.T. Club and sailing his Marshall 22 catboat. . . . Dodie and **Bob Casselman** write from Cape Cod that Bob's miracle recovery progressed and his exercise schedule now includes walking a mile per day. Bob's book, *Continuum*, generated enthusiastic and exciting comments. To get your copy write them at Box 272, Cataumet, MA 02534, and they will interrupt the pleasures of visiting two new grandchildren to send you your autographed copy.

Hank Landwehr lives at Long Beach, Calif., where he serves as chief chemist for Twining Laboratories. . . . **Bill Pulver** and Adie have made their careers in and around Lakeville, Conn., where as entrepreneurs they have made contributions to better the commercial and civic situations in their community. Their 1980 autumn program includes providing a dependable source of fuel oil to keep people warm this winter, and they are preparing to provide large numbers of General Motors autos as the current vehicle recession ends.

Bud Croshere moved from Santa Monica, Calif., to a town house in Irvine, possibly so he wouldn't have to mow the lawn any more. Because of his career in aeronautics, he was especially thrilled and inspired to see the TV presentation of the Saturn fly-by. Bud is busy these days building furniture and model ships, and he is planning solar heating for an association of town houses. Bud said **Orv Dunn** had moved to Broken Bow, Neb., but neither Bud nor I could guess why Orv chose a community named with such question-provoking potential. For instance, do you suppose Orv has taken up archery? . . . or started a repair shop for broken arrows? Come on, Orv, when you read this, drop us a note so we can relay your good words to your interested classmates. — **Hal Seykota**, Secretary, 1421 Calle Altura, LaJolla, CA 92037

40

Once again the deadline for class notes but little news to report from classmates . . . writer's cramp, or something?

Our former class secretary, **Al Guttag**, writes regarding his sons — all are different although all are scientifically inclined. The oldest, Eric, is now a successful patent lawyer, and the second, Karl, an equally successful electrical engineer. In Al's opinion, only his third son, Mark, had the qualification to be considered as an undergraduate at M.I.T. because of his outstanding academic record and extracurricular activites in high school, which included being a National Merit Scholarship finalist this past year. Unfortunately, he was turned down by the Institute for "insufficient outside activities." Al thinks this decision unfair and asks if the Institute's admission policies may be affected by the fact that government grants might be terminated unless it adheres to "reverse discrimination." Mark selected a small liberal arts college, Carleton, in Northfield, Minn.

It is most difficult for us to realize what damage the federal bureaucracy has done, not only in the field of education, but in all other activities in our society. — **Donald R. Erb**, Secretary, 10 Sherbrooke Dr., Dover, MA 02030

41 40th Reunion

Technology Day, a traditional feature of reunion week, will be Friday, June 5. This year's program will focus on the automobile. We hope to see you there. — **Henry Avery**, Secretary, Koch Carbon, Inc., 888 Worcester St., Wellesley, MA 02181

42

Our thanks to 24 classmates who sent in news in response to my recent mailing. This gives us enough "honest" intelligence from the class so that we will not have to invent news. But if you have not used that prepaid envelope, send more news.

Jim Littwitz was among the first to respond to our pleas for news. He wrote (in October) that he was recovering from a quadruple by-pass operation. Jim always does things in a big way, but this was a bit much in reply to a simple request for some class news! He is doing fine and is back at work.

Lois and **Alan Macnee** are living in Albuquerque for a year, from September 1980 to August 1981. Alan is on a sabbatical leave from his position as professor of electrical engineering at the University of Michigan. He is at Sandia Laboratories designing custom instrumentation chips for microwave bipolar integrated circuits. About 900 transistors, diodes and resistors are required on a quarter-inch square chip which (he hopes) will be fabricated by next spring. Kay and **Bob Osborne** visited with the Macnees last spring. Bob has been working at Los Alamos Laboratories ever since he completed his Ph.D. in Course VIII.

In an update, **Dave Baltimore** tells us that he is still running the family television station, WBRE-TV in Wilkesbarre, Penn.; he has sold his radio station and has added the Digital Video Production Division which does TV commercials and programming.

Since retiring, **Lawrence Beckley** has organized his life into three time slots. One third of his time is taken up with bird carving, another third with looking after his two houses in Winchester and Colrain, Mass., and the rest is "just miscellaneous." Sounds like a good arrangement. . . . Another retiree, **Lawrence Valade**, now an educational consultant to the Michigan State Senate, spent his first career as as an instructor, then a principal, and finally superintendent of schools in Michigan. **Jon Noyes** is still beating the drums for Corpus Christi which he always describes as a beautiful city having "great hunting, fishing, golf, tennis and other activities." I keep wondering what the other activities may be! The Noyeses recently returned from a good tour of eastern Oregon, Washington, and the Banff Lake area. Jon is still actively stock brokering, doing a little financial consulting, and running his "few" cows.

Jim McCellan took early retirement from his position as vice-president for Oklahoma Operations of the Weyerhauser Co. and moved back home to Harvard, Mass. He has shifted his career interest to real estate and is now working with the end product of growing trees and making lumber — selling houses. . . . Was pleased to hear from **Bob Fay** that all of his seven children are gone from home, the last three are now in college — at Cornell, Cincinnati, and Cleveland State, respectively. Bob is still working hard at patent law but now does a considerable amount of writing in the general law and the patent law fields.

Bob Seamans will be stepping down as dean of the School of Engineering on June 30, 1981, but will remain at M.I.T. as the Henry Luce Professor of Environment and Public Policy. Bob's record of accomplishment as dean of the engineering school has been outstanding, and we wish him the very best of success and satisfaction in his return to active teaching.

Bob Jacobson has been in Washington, D.C., for the last eight years. Currently he is with the FAA on a joint project with the National Weather Service and the U.S. Air Force planning for the new generation of weather radar equipment for the late 1980s. Bob's daughter Marion is a freshman at Tufts, so he'll be back visiting in Boston once in a while. His other daughter Sabina is with the U.S. Department of Labor's library doing cataloging and acquisitions. By now the whole family are happy Wahington transplants.

With good news, of course, we also get obits. Thanks to **Jim McCellan**'s reporting, we now know that **Bill Hanse** passed away in Altadena, Calif., in August 1979. **Don Berkey**'s letter tells us that **Mike Hook** died suddenly on October 30, 1980. Mike was a transfer student and worked for General Electric Co. in Erie, Penn., throughout his career. From Kat Gillooly, we learned that her husband, **Dick Gillooly**, succumbed to cancer in March 1980. Dick worked for McDonnell-Douglas Astronautics in St. Louis and participated actively in the space program from the first Mercury flight up through the Sky Lab Program

Finally, the *Boston Globe*'s long article and a letter from **Lou Rosenblum** accented the news of **Marty Levene**'s death from cancer after a long and courageous fight. While we know Marty as our ever prudent class treasurer, he was a nationally renowned cancer radiation specialist. At his memorial services, Dr. Sam Hellman, one of Marty's collegues, spoke of Marty as a man ". . . of judgement, integrity, wisdom and humility . . . a doctor's doctor and a gardener's gardener . . ." Our most sincere sympathy to the wives and families of these classmates.

Again, my thanks for the bumper crop class news. More will apear in next month's notes. Though you will be reading this in February, I'm writing in November and wishing everyone a happy, healthy, and prosperous new year. — **Ken Rosett**, Secretary, 191 Albermarle Rd., White Plains, NY 10605

43

Loring Hosley (Course II) writes: "Currently back in college to get another degree and my license to be a doctor of chiropractic. In the process I'm learning how to live to be a healthy 100 years old." He plans to enjoy a long and well-adjusted life.

From beautiful northern Vermont **Augustin Root** (also Course II) reports that early retirement is exciting. He has rebuilt his church's organ, rewired a small theater, worked on local health planning, and made consulting trips to exotic paradises of the Pacific. By a singular coincidence, Gus Root's picture is next to your secretary's in the 1943 *Technique*.

Keep those cards and letters coming, if they ever get started. — **Bob Rorschach**, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

44

After shoveling about six inches of heavy wet snow which arrived during the night, I began to envy those who live in warmer climates. Cool air is invigorating to a point, that is, until one must cover the skin to avoid frostbite. Thank goodness we all like different weather, so that population densities are scattered all over the globe rather than concentrated in one selected area.

Flap Facts: **Joseph A. Alexander** (Course I, government war student) relayed the following: "president of Alexander Systems, business consultants and business brokers; director of Abacus Administrative Assistance Co.; president of Newton Taxpayers' Association; publisher of the Business Efficiency Survey Kit; author of *Aids to Management*."

Letter: **Arthur F. Peterson, Jr.**, notes that he and Ronnie are planning to join us for our Mexican trip in March; that they spent two weeks exploring the Hawaiian Islands; that they travel extensively around the U.S., helping to establish chapters of Compassionate Friends; that they received a letter from our ministerial classmate **Bob Meier** expressing interest in their work; that Art's latest

An Engineer on Heart Disease: Some Comments on Prevention

Dr. **W. Gerald Austen, '51**, chief of surgical service at Massachusetts General Hospital, talks about the human body in engineering terms — the heart as a series of pipes and pumps — as befits a mechanical engineer, the field in which he earned his M.I.T. degree.

That fact, and some current observations on heart disease (M.G.H. does more coronary by-pass surgery than any other operation) were the intriguing elements in an interview with Steve Hoffman, staff writer for the Akron *Beacon Journal*, when Dr. Austen returned to his hometown for a late-summer visit in 1980:

☐ The percentage of all deaths attributed to heart disease has been decreasing for the past six years — "an encouraging sign" that new research and new drugs, and especially preventive medicine, are having an effect.

☐ Though they're very real, the effects of cigarette smoking on the risk of coronary heart disease and stroke are reversible. Even those who smoke a pack of cigarettes a day show better statistics within six weeks of stopping; and "within a year they will almost be back into the statistical range for those who never smoked," Dr. Austen told Mr. Hoffman.

☐ The effects of diet and exercise are still a question. "Exercise is good, but it should be started early in life and it should be regular — at least every other day — and not sporadic," said Dr. Austen. "I'm very much opposed to excessive exercise and I'm not much for jogging."

☐ Stress? All "active and committed" people encounter it, and Dr. Austen thinks "there is nothing wrong with working hard and having a certain amount of stress if you are basically happy with what you are doing." The problem comes with long-term stress due to a role that a person does not find satisfying.

All these conclusions tend to be tentative, said Dr. Austen, because the kind of long-term statistical research that could isolate the causes of heart disease has been done only in the last four decades — not really long enough.

hobby, scrimshaw, is improving by leaps and bounds but has a long way to go before he can compete with what he saw in Hawaii.

Nostalgia: From *Tech Talk* "40 Years ago": "A recent straw vote conducted by *The Tech* indicates that the majority of students favor Wendell Wilkie (66.5 percent) as the next president of the U.S. over Roosevelt (29 percent). Most Wilkie supporters are not confident that their candidate will be successful."

Alumni Council: In October Paul E. Gray was the speaker for the largest group ever to attend these monthly meetings. He directed his talk to the help needed, especially during the next two decades, by the alumni in recruiting the ablest of students and faculty, providing adequate housing, and financing of the Institute's operations and future needs.

Reunion Plans: **Andy Corry** recently served dinner, with the help of his sister-in-law, to your ongoing reunion committee. Marguerite and **Ed Ahlberg**, Jane and **Lou Demarkles**, **R. J. Horn**, Ruth and **Norm Sebell**, Edna and **Stan Warshaw**, and your secretary were there. We all are aware that it is not too early to begin planning for our 40th Reunion which will start on campus and conclude at another location. Please write a committee member indicating your preference of locale and length of stay for the off-campus portion which will begin after the Technology Day luncheon, 1984. (We'll even listen to the Orwellian doomsdayers.) — **Melissa Teixeira**, Secretary, 92 Webster Park, West Newton, MA 02165

46 35th Reunion

We are pleased to report that **Richard C. Mulready** has been appointed vice-president of technology for UTC's Pratt and Whitney Aircraft Group. Mr. Mulready joined the company as an analytical engineer in 1946 following graduation from M.I.T. with a degree in aeronautical engineering. Richard moved to Pratt and Whitney in 1952 where he worked as an assistant project engineer in the development of ramjet and other aircraft engines. In 1958, Richard became project engineer for the first liquid hydrogen/oxygen rocket engine, the RL10, which later became an important engine in the U.S. space program. He was named program manager for the company's space shuttle engine program in 1970, and in 1972 he became manager of new business development, with a promotion in 1976 as the director of technical planning. Mr. Mulready was one of three who received the coveted 1974 Goddard Award presented by the Institute of Aeronautics and Astronautics for significant contributions to the development of practical LOX-hydrogen rocket engines.

Henry F. Lloyd retired as captain after 30 years with the U.S. Navy. He now has a second career as college administrator at Flagler College, a small liberal arts college in St. Augustine, Fla. . . . **Louis Roberts** was a visiting engineer and visiting lecturer at M.I.T. from August 1979 through June 1980. He is now director, Office of Data Systems and Technology, Transportation Systems Center, Cambridge, Mass. . . . **Donald E. Robison** was awarded the Harold E. Lobdell Distinguished Service Award by the M.I.T. Alumni Association on June 5, 1980, for his outstanding leadership in the Tampa Bay area and his service to the Alumni Association of M.I.T.

Technology Day, a traditional feature of reunion week, will be Friday, June 5. This year's program will focus on the automobile. We hope to see you there. — **Russell K. Dostal**, Secretary, 18337 Palm Circle, Cleveland, OH 44126

47

Something to warm our winter from **John Kellett**, written in July on a colorful menu (with an unusual beaver on the cover) from the M.I.T. Club of Hong Kong Alumni Dinner: "I am 60 percent through a five-month assignment here working on the development of a new joint venture power station project, to meet the rapidly growing electricity demand in Hong Kong. Not the best time of the year to be here, but better than it's been in Texas lately. The M.I.T. Club of Hong Kong is being reactivated after a five-year dormancy. This was their first function, a fund-raising dinner graced by the presence of I.M. Pei and his wife. The club members are practically all Chinese — few expatriates. Most other U.S. university clubs here are the opposite. The affair had fewer words by Mr. Pei on architecture and more by everyone on fund-raising than I would have liked, but a pleasant evening all in all. Note Chinese beaver on the front." John's return address was Ice House Street, Hong Kong. . . . **John Karmazin**'s *News and Views* illustrates the international character of his cooler business with color pictures from every continent but Africa, including a (now) familiar shot of Rio. The beaver this time is shown putting energy conservation savings in his piggy bank.

Earthworks, a publication of Haley and **Harl Aldrich** , lists projects from Singapore to Sanford, Maine, for which H&A is providing geotechnical engineering services. Described in detail are the Trident drydock in Bangor, Wash., and the Long Wharf Hotel project in Boston. Harl joins the Corporation as an ex-officio member for the coming year. He took time out from his duties as Alumni Association president to have dinner with the **Arthur Schwartz**s, when they came to town in November. Also involved in the festivities was **Dick Knight**. Harl, Dick, and Art joined **Mary Frances Wagley**, **Bob Hagopian**, **Marty Haas**, **Claude Brenner**, **Arnold Judson**, **Ed Kane**, **John Karmazin**, **Herbert Kay**, **Bob McBride**, **Don vanGreenby**, **Jack Rizika**, and **Ginny Grammer** at Paul Gray's inauguration and the Alumni Officers' Conference.

Arthur Schwartz received the Morgan Award as a member of the Educational Council. **Mary Frances Wagley** and **Ginny Grammer** also attended the AMITA dinner (Association of M.I.T. Alumnae). Mary Frances is now a vice-president of the Alumni Association, thus keeping alive the Class of '47 dynasty founded by Claude and continued by Harl. . . . **Claude Brenner** has been elected to a five-year term on the Corporation, following his one-year ex-officio stint. Since 1975, he has been chairman of the Committee to Strengthen Alumni Involvement with the Institute. . . . The American Society for Quality Control awarded its Edwards Medal to **Robert W. Peach**, manager, Quality Division of Sears, Roebuck, and Co.'s development and testing laboratories, "in recognition of his outstanding national and international leadership and achievements in the application and advancement of the science and profession of quality control in the manufacturing and merchandising of consumer products, and for his significant contribution to the administration, organization, and training activities of the American Society for Quality Control." . . . **Jordan Baruch** received an honorary degree from the Franklin Pierce Law Center, Concord, N.H., last May.

Ginny Grammer (c'est moi) spent a month in Brazil last summer, attended daughter Margaret's wedding, and, with four other family members, joined the newlyweds on their wedding trip, traveling in a rented van and camping in a rented tent in campgrounds along the coast between Santos and Rio. Signs prohibited camping on the beach itself for some kilometers; the beach was the highway in that section. Very strange to meet buses and be passed by trucks while driving on the sand of a beach. The coast is wild and beautiful, having only recently been opened up to travelers with the new "trunk road" (mostly dirt). The Camping Clube do Brazil campground just outside Rio is across the road from the most beautiful beach in Rio, in Barra di Tijuca. On one side of the campground is a new compound of townhouses; on the other a collection of eight 30-story apartment buildings. Rio is spreading out. In Rio, I had lunch at the Swiss Consulate with Colonel Russell Coile, '38 and his son and later enjoyed dinner at the Coiles'. They live in Urca,

one of the quiet sections of Rio, which lies at the base of Sugar Loaf, somewhat removed from the rest of the city. I have one problem with Brazil: the next time I go, I may stay. Please keep the messages coming. I appreciate your help in providing grist for the old mill. Love to you all. — **Virginia (Ginny) Carter Grammer**, Secretary, 62 Sullivan St., Charlestown, MA 02129

48

John Avallon sends a note describing his position as president, Electrical Products, GTE Sylvania, which includes the following groups: Lighting, Electrical Equipment, and Precision Materials. . . . **Tom Jabine** has retired from a career of 30 years as a statistician for the Federal Government — with the Census Bureau, the Social Security administration, and most recently with the Energy Information Administration. Tom will continue to be active with various teaching and consulting activities. . . . **Ed Kratovil** is enjoying the life of a Carolina gentleman farmer. This year's big project is building a garage and workshop from the ground up, a rectangular building about 16 by 32 feet. "Finished the roofing boards recently — maybe M.I.T. should have a woodshop — or does it?"

Arnold Singer is regional chairman of the M.I.T. Educational Council for the Houston area. . . . **Bob Sandman**, whose business is in Braintree, Mass., has been named vice-president of the Electrical Apparatus Service Association in St. Louis. . . . **Bob Lewis**'s company in Woodstock, Vt., manufactures leather-bound bibles and gilt-edged religious books. He employs 65 people, and sales have expanded eight times during the past ten years. . . . **John Brady** died in September. John was 63 and had retired as a naval architect and marine engineer from the Navy Department. He was one of the designers of the hydrofoil.

Harry Ottobrini and I spent two hours discussing franchising opportunities, and Harry is interested in a mobile dry cleaning business. He already charters his sailing yacht in the Caribbean. . . . **George Clifford** spent a couple of weeks in Arizona with his son. They visited the Grand Canyon. — **Marty Billett**, Secretary, 16 Greenwood Ave., Barrington, RI 02806

49

Winter is about to melt away and spring is greening. Can Alumni Day be far away? No, it isn't, and it's lots of fun to get back and see the new Tech. And you can end up at the AC49CP (Annual Class of 1949 Cocktail Party) just before the Pops. Will that bring back memories?

Anthony Gabrielle has joined Gulf States Utilities Co.

For you trivia lovers and sharp-eyed classknowers: *Technique '49*: Setember 24: picture, lower right corner: Who is the speaker at the microphone? Send your entries to — **Paul E. Weamer**, Secretary, 5130 Regent St., Madison, WI 53705

51 30th Reunion

Once again it has become my turn to prepare the notes for our class. I have a few cards and letters but could sure use more input from all of you out there.

Christian Bolta left Argonne National Labs and has joined Combustion Engineering, Inc., in Stamford, Conn., as director of technology strategy. This involves evaluating the impact of new technology on the company during the next 20 years. (How's that for a long term contract?) Christian says that he is glad to be back in New England with the hills, rivers, and valleys instead of the flat lands and snow. His wife Joy also loves it in New Canaan. Funny, I remember snow in Connecticut, but it has been a long time since I was in snow, so maybe things have changed. Best of luck in your new position. . . . A very short, concise note from **Ed Richard**: "Principal in Mountain Engine Service, Inc., distributor for Perkins diesel engines in Colorado and Wyoming." How's that for a newsy letter? Good to hear from you, Ed. . . . On the politics side, our own **Gerald E. Lyons** was running for library trustee in Dedham, Mass. Let us know how you made out, Gerald. Did you get swept in with the landslide conservative vote?

Also from the fine state of Massachusetts, we had word that **Walter O. Davis** was named director of the Department of Public Works in Brockton. Walter was previously with a paving company but can now make sure all the potholes down the main street will be repaired posthaste. Our best to you in your new position, Walter. . . . **Melvin Stone** of M.I.T.'s Lincoln Lab is giving a talk before the Power Engineering Society. Melvin has been working on radars ranging from HF to microwaves. He is a member of the Surveillance and Control Division where he is currently leader of the Radar Sensors Group. Sorry I missed your talk, Mel. Since it was last May, I guess I am a little late. . . . **Fred Bumpus**, I have learned through my secret channels, was named to the post of chief executive officer of Arkwright-Boston Manufacturers Mutual Insurance Co. . . . Also through the same wire service, I learned **David I. Caplan** was elected a vice-president and director of development for computer operations of Perkin-Elmer Corp. in Norwalk, Conn. Our best to you both, Fred and David.

Out here in sunny California, the home of Ronald Reagan and clear smogless atmosphere, **Ted Porush** has changed positions and is now with Braun Co. in Alhambra. In fact, my daughter Karen and his daughter Julie are roommates at UCLA. Small world. I sold my printing company and am now a management consultant currently with a jewelry company as vice-president, operations.

Technology Day, a traditional feature of reunion week, will be Friday, June 5. This year's program will focus on the automobile. We hope to see you there.

That is all for now. Let's hear from you more often. — **Mark Franklin**, Assistant Secretary, 291 S. Euclid Ave., Suite PH-2, Pasadena, CA 91101; **Sam Rubinovitz**, Secretary, 3 Bowser Rd., Lexington, MA 02173

54

We have just had our first snowfall of the season in Boston, and it is only November 18. We had very little snow last winter and hopefully this does not mean we are in for a lot of snow this year. In the meantime, we have a few notes from fellow classmates to share with you.

Dave Wiesen, Course XV, reports that he, his wife Muriel, and family visited Australia last December and had planned to visit Indonesia as well but had to cut their trip short due to a death in the family. In March, Dave's wife Muriel tore the ligaments in her left knee in a skiing accident in Quebec which he reports will be about one year in healing. Dave is hoping that 1981 will be a better year. . . . **Don McGrath**, Course III, reports that he is manager of materials engineering at Air Research Manufacturing Co. in Torrance, Calif.

Hank Hirsch, Course VIII, reports he was recently elected a fellow of the Gerontological Society presumably in recognition of his graying beard. He also reports he was recently a member of the Public Affairs Committee of the Federation of American Societies for Experimental Biology and the American Physiological Society. Hank's picture in our yearbook shows him to be clean shaven, so it sounds like we might not recognize him now.

Dr. **Jerome B. Cohen**, Course III, a Frank C. Engelhart Professor of Materials Science at Northwestern University was named a fellow of the American Society for Metals. The American Society for Metals established the honor of fellow to provide recognition to members for their distinguished contributions in the fields of metals and materials and to develop a broadly based forum for technical and professional leaders to serve as advisors to the society. Jerry was selected for his outstanding contribution to the understanding of structure-property relationships in materials, particularly to utilization of X-ray diffraction theory and techniques to better characterize materials. We congratulate Jerry for receiving this impressive honor.

It is with sadness that we report the death of **John McGrew, Jr.**, on October 16, 1980, in Schenectady, N.Y. John is survived by his wife Elizabeth, a daughter, and two sons. He was a graduate of Course IX, held a graduate engineering degree from Syracuse University, attended Rensselaer Polytechnical Institute, and was a registered professional engineer in the state of New York. He had lived in Schenectady for the past 18 years. John was co-founder and president of Shaker Research Corp. in Ballston Lake, N.Y. He was an internationally recognized authority on lubrication and authored numerous papers and technical journals. He also organized national technical symposia on lubrication and was a lecturer at such symposia. Our sincere condolences go to his wife and family. — Co-secretaries: **William Combs**, 120 West Newton, Boston, MA 02118; **John Kiley**, 7 Kensington Rd., Woburn, MA 08101; **Louis E. Mahoney**, 52 Symor Dr., Morristown, NJ 07960; Dr. **Dominick Sama**, Chestnut Hill Rd., Groton, MA 01450

55

Sometimes, as I sit at my desk looking over a pile of paper, I speculate on the ways we are trapped by habit. If only I had taken ballet lessons, today I might be dancing on the wharves of Sarawak. As it is, my memoirs would have to be expanded for the *Reader's Digest*. In any event, whether you are a magnate of industry or a magnet of bad times, please send some news to your class secretaries.

George A. Goepfert and his family are well and enjoying life in Hong Kong. Their son Ian returned to the U.S. this summer and is enrolled as a freshman at Texas Tech in Lubbock. . . . **Roger S. Reiss** has moved into the fuels and energy group at Stone and Webster Corp. He is handling the equipment and hardware for the ethanol and synfuel projects that Stone and Webster is conducting for the Department of Energy. . . . **Gerald P. Maloney**, who is senior vice president for finance of American Electric Power Service, has been elected to the board of directors of Columbus and Southern Ohio Electric Co., which American Electric Power Co. acquired last May. He will also be the principal financial officer of CSOE.

RCA has announced the appointment of **Ed L. Elizondo** as manager, Integration and Test, at RCA Astro-Electronics in Princeton, N.J. In his new position, Ed heads a group of engineers and technicians responsible for the integration and test of two Dynamics Explorer spacecraft. Since joining RCA in 1967, Ed has held several engineering positions including the responsibility for the communications system analysis of the Dynamics Explorer spacecraft.

In a stunning election upset, your Winchester class watcher has been selected by the membership of the Institute of Electrical and Electronics Engineers to serve on the board of directors. He will represent 30,000 members of seven technical societies of the Institute, as well as the interests of the over 200,000 IEEE members worldwide. In view of the dramatic voter victory, which was announced before the polls had closed on the wharves of Sarawak, political pundits predict a resurgence of the closely aligned group, the Magnetic Majority, which is guided by the right-hand rule. — Co-secretaries: **Marc S. Gross**, Winding Road Farm, Ardsley, NY 10502 and **Allan C. Schell**, 19 Wedgemere Ave., Winchester, MA 01890

After two years as dean of American University's College of Arts and Sciences and three years as provost, Richard Berendzen, '61, was named president last January 13. He makes it a demanding job, with quiet moments in his office (above) a cherished rarity. (Photo: Ann Stevens from American University)

Richard Berendzen, '61: American's Man of the Hour; But When Does He Sleep?

In a brief moment between appointments and telephone calls this spring, **Richard Berendzen, '61**, walked out of his office to catch some fresh air on the American University campus in Washington. His discoveries: "a street light burning (why?), a sophomore who 'loves American University,' an athlete who dislikes the gym, a professor proud of a new grant, and a lost cab driver" — some trivia, Dr. Berendzen would admit, but all grist for the mill of a college president only three months in office.

Dr. Berendzen went to American University in 1974 as dean of its College of Arts and Sciences; he studied and taught at Harvard after graduating from M.I.T. (in physics), and then went on to become head of the Department of Astronomy at Boston University. He'll be inaugurated as American University president on September 18 — and he will bring to his job a reputation for intensity and high standards.

He thinks his intensity comes from his knowledge of astronomy — his major field at Harvard: "I have a feeling of the time line on which we are all living," he told Jody Goulden of American University's Office of University Relations this spring. "'Too many people spend too much of today worrying, working so that tomorrow will be just like yesterday. . . . The goal should be to be the best one can be — not just to be," he said.

His goals for American University are like that: "Good things are going on, a sense of institutional pride is developing. . . . There's a real possibility that by the mid-80s we'll become the best independent university in this part of the country. We won't be Harvard on the Potomac," he told Ms. Goulden, but "if we reach that level of aspiration we'll have a lot to be proud of."

Dr. Berendzen is a champion of high educational standards. "The last 15 years have been a national disgrace," he says. "There's been a demonstrable decline in the quality of education," he told Sheila Taylor of the *Dallas Morning News* (Dr. Berendzen's home town) this spring. Commenting on student activists of the 1960s, he says, "When society is intimidated by youth, society loses self-respect"; and on grade inflation: ". . . when everybody's honored, nobody is."

At M.I.T. Dr. Berendzen switched from electrical engineering to physics because he found he was "more interested in why something worked than how it worked." And he learned "several important things as a student," he says: "One doesn't receive good grades by trying but by succeeding"; he could survive on three to four hours of sleep a night; and "one can be efficient, social, and civil and yet not waste a lot of time on small talk."

Those lessons have stuck with him. Dr. Berendzen's "cherished personal time" is between 9 p.m. and 2 a.m. on Sunday — "no phones or letters or people; just my office and me. Time to review and plan, assess progress and set goals."

56 — 25th Reunion

By now you have been invited to and reminded of the once-in-a-lifetime 25th Reunion of June 4-7, 1981. We're expecting to break several records — for attendance, reunion gift, athletic and other measurable accomplishments — but the real test is your own enjoyment and advancement. The promised panel discussion on "Technology in Our Lifetime" for Saturday morning, June 6, is developing into a very significant event. The topics are obviously essential to your professional and personal lives and it's especially meaningful to hear it all from our own classmates, who are not only reporters but the makers of the technology being discussed.

The Saturday afternoon outing at **Bill Northfield**'s spectacular Osterville estate will alone be worth the trip. We hear that **Ed Baker**'s Bermuda Bonus Stopover is nearly filled (see details in the January *Review*). The early returns for the Reunion Gift efforts of **Roger Borovoy**, **Mickey Reiss**, and **Walter Frey** are most encouraging, but there's still a good way to go towards our new goal. Keep in mind the inflation pressures on M.I.T.; such gifts are essential to maintaining the excellence which we continually enjoy as alumni. Some of us may feel upset over the fact that IRS taxes as "capital gains" what is really only the inflated prices of our assets. One solution is to donate those inflated assets (stocks, real estate, artworks, coins, stamps, etc.) to M.I.T., allowing you to write off the entire inflated value as a donation. For some of us, this can amount to having Uncle Sam contribute at least two dollars for every one of ours (or, better yet, $2,000 for our $1,000).

Some news has been coming in, but we always appreciate more from you. **Hal McKittrick** left Perini last summer, after 20 years. He's now vice-president for mid-Atlantic operations, Manganaro Corp., in Columbia, Md., a large wall and ceiling contractor. . . . **Merlin Lickhalter** helped form and is president of JRB Architects in St. Louis. This is part of JRB Associates/Science Applications, Inc., an international professional services group. Merlin has been very active in M.I.T. alumni affairs in St. Louis and serves on several national committees. . . . **Frank Foster III** is assistant chief of the Industrial Division of the Panama Canal Commission, which he reports operates in the black while promoting U.S. relations and helping a developing country. . . . Dr. **Robert Holden**, clinical professor at the University of Vermont, is spending a year at Yale studying epidemiology.

We noticed **Stan Wray**'s picture in a recruiting ad for Aerospace Corp. of El Segundo, Calif., where he is an engineering specialist in the Project Management Applications Office. . . . **Bill Grinker**, our reunion chairman, was recently quoted as observing that ". . . used software is the best kind, . . . it works." Bill is president of the American Used Software Co., the latest component of the American Computer Group in Boston. His group is already the world's largest dealer in DEC equipment, and this new firm will feature the DRS data base management system for DEC computers. — Co-secretaries: **Warren G. Briggs**, 33 Bancroft Rd., Wellesley Hills, MA 02181 (617) 235-7436; **Bruce Bredehoft**, 7100 Lanham Ln., Edina, MN 55435

59

Pleading for mail has at last drawn some response, and I thank you. Again, I apologize for the long time between your writing and the appearance of your news in Class Notes. Don't give up; eventually your message will appear.

A press release dated June 5, 1980 from the Alumni Association states that **Allan Bufferd** was awarded the Harold E. Lobdell Distinguished Service Award for valuable service to the Alumni Fund, the M.I.T. Class of 1959, and the Alumni Association. Congratulations.

Phil Beach, Course VI writes that he has just

changed jobs — from the Campbell Soup Co. to SHV, a large Dutch group that owns MAKRO, a cash-and-carry food wholesaler in Brazil and other countries. Although Phil doesn't indicate it, I assume he is working for MAKRO in a multinational capacity, since the last address I have for him is Brazil. . . . Since March 1980, **Donald Mott**, (Course VI) has been president of Phantos Research, Inc., an organization engaged in data processing services, consulting, and research. . . . From **Robert Doleman**, Course VIII: "After 20 years of messing around the world with the Army, etc., I am changing diet and lifestyle in Hawaii." No comment.

Bob Weiss writes that he is finishing his second term as a selectman in Lynnfield and that he is looking forward to his retirement from town politics. He also says that his company, Physical Sciences, Inc., is now seven years old and is planning a building in Andover, Mass., where M.I.T. grads are always welcome. . . . **Ken Taber**, Course III, writes that he and his family very much enjoyed our 20th Reunion, except for the gas crunch on their trip home which caused them to spend one extra night on the road. He and Cindy are quite busy. Ken is head of Catalytic Engineering's Materials Engineering Group and has been named to ASME's Section IX Committee; Cindy has started graduate school at Villanova (library science), as well as working full time at their township library.

Carlos Prieto, Course III, writes the most fascinating class note I have ever received, so I quote it in its entirety: "After devoting 18 years to the steel industry of Mexico and having been president of a 1.5 million tons per year company in Fundidora, Monterrey, I resigned from that position as well as other business positions (in 1978) to become a professional cello soloist. At M.I.T. I had been first cello and soloist with the M.I.T. Symphony in 1957. In my new capacity I have already played in Germany (East and West), Holland, Spain, Finland, USSR, Hungary, Czechoslovakia, Bulgaria, Canada, and Latin America. In 1980 I played with the San Antonio Symphony Orchestra and the Atlanta Chamber Orchestra."

Bruce Silberg says that he is alive and well in Weehawken, N.J. and is currently involved with New York City's school volunteer program. He goes to a junior high school near Lincoln Center twice a week to work on a one-to-one basis with students who require remedial assistance.

Phil Richardson, our class agent, writes a long, information-packed letter. As class agent, Phil corresponds with all who contribute to the Alumni Fund in order to express the Fund's "thanks" and to exchange information and news for class notes. As such, he is a valuable input for this column. So please make my job easier — contribute to the Fund and let Phil (and me) know what you are doing. He also writes that he, as head of the Investment Banking Group at Ehrlich-Bober and Co., Inc., travels all over the United States and sometimes to Europe. During these travels, Phil is willing to stop and meet with '59ers to swap stories about Tech and thank you for past contributions to the Fund. And I'm sure he would not be reluctant to accept new contributions. Phil closes his letter with an invitation to call him at work (212-480-9331); and he will "buy you breakfast, lunch, or dinner" and "swap stories about Tech." Sounds like a great deal to me. I'll make a similar offer — if any of you are in the White Plains, N.Y. area, give me a call at 914-696-5048, and I'll also buy you breakfast, lunch, or dinner in exchange for conversation and a contribution to the Fund.

The last news is not pleasant. The Alumni Records Office informs me that **Michael F. Garnier**, Course III, died in a boating accident this past September. . . . Please keep your cards, letters, and notes coming. — **Larry Laben**, Secretary, 310 Rockrimmon Rd., Stamford, CT 06903

61 — 20th Reunion

As you now know from a carefully planned series of mailings, the 20th Reunion is off and running. Late in October a small group from the Boston area got together and worked out what seems to be a very pleasant way to spend a late spring weekend. The objective is to get together with old friends and classmates to compare careers, families, and the effects of 20 years. Major events that have been scheduled are Tech Night at the Pops, cheap rooms in New House (all air-conditioned), a Friday cocktail party at the M.I.T. crew house overlooking the Charles, Saturday supper at the New England Aquarium, and a boat cruise up the Charles to a dance on campus. If you want to bring your kids to Boston, they can stay with you or they can enter a camp run by the Institute with all the athletic facilities open and all meals and supervision for 24 hours a day. I may send my kids to the reunion and join the camp myself.

We have sent out a questionnaire to the class. It will be fascinating to see how we answer questions that were answered by the class ten and 20 years ago. Please fill yours out and send it on. I will report on the results after the reunion.

Pete Buttner, who we expect to come down from darkest Vermont, writes that he is still manager of planning for Boise Cascade's Specialty Paperboard Division in Brattleboro. He says that he likes the work and the Vermont lifestyle. . . . **Andy Zeger** seems to have the first child in the class to come to M.I.T. He is Kenneth Zeger who is a freshman. Andy writes, "Inflation of college costs is a painful reality." Andy hopes to come to the reunion. **Terry Langendoen** writes, "I find that I am no better or worse than my linguistically naive colleagues in the English department at Brooklyn College in teaching remedial writing and grammar. This year, rather than teaching the subject, I am serving on a city-university wide faculty committee on remediation. I strongly suspect that my ideas will be no better or worse than those of my fellow committee members."

Our class politician, **John Sununu**, who is associate dean at the College of Engineering of Tufts University, is getting active in referenda these days. He was involved in the effort (successful) to defeat an anti-nuclear power referendum in Maine last fall. He was on TV in Maine arguing for the continued operations of the Maine Yankee reactor several times.

See you all this June. — **Andrew Braun**, Secretary, 464 Heath St., Chestnut Hill, MA 02167

63

My cup runneth over this month! I have a real letter (every now and then you respond to my pleas) as well as the usual news releases and envelope flaps. **Steve Ditmeyer** is living proof that the art of letter writing is not dead. He writes (in his own hand) that he married Marty Draper, southeast regional director of the M.I.T. Alumni Association, in May 1979. The wedding was at the M.I.T. Chapel, of course. The Ditmeyers spent the next eight months in Alaska, where Steve was acting general manager of the Alaska Railroad (which is owned by the Federal Railroad Administration). Steve and Marty have been in Washington, D.C., since last March, and Steve is associate administrator for research and development for the FRA. He sees quite a bit of **Lou Thompson**, who is associate administrator for Intercity Programs for the FRA, and **Jack Harman**, who is director of industry studies in the Office of the Secretary of Transportation (and who was best man at the wedding). Many thanks for the letter.

We also have a note from **Patricia Selby Marzilli**. She reports that she has now moved to Atlanta, with her husband Luigi, who is professor of chemistry at Emory University. Pat has been doing inorganic research as a post doc in her husband's group and is working at home on a book series, *Advances in Inorganic Biochemistry*. The Marzilli's children, Alan, Veronica, and Alisa are 10, 8, and 4. . . . **William A. Barnett** is a research economist at the Board of Governors of the Federal Reserve System in Washington, D.C. He is also a visiting lecturer at Johns Hopkins University and a research associate at the University of Chicago (under an NSF grant). Last summer Bill was visiting lecturer at the Universite de Droitin Aix-en-Provence (near Marseille) in France. He was editor of the September 1980 and January 1981 editions of the *Journal of Econometrics*. His book, *Consumer Demand and Labor Supply*, will be published shortly by NorthHolland Publishing Co. Whew, sounds like you have been keeping busy!

Ed Dudewicz is also a journal editor, in this case the new *American Journal of Mathematical and Management Sciences*. The first issue, published by American Sciences Press, of Columbus, Ohio, came out in January 1981. The journal emphasizes readability and usability at the leading edge, and Ed says he hopes for many alumni contributors and subscribers. Anyone interested in the journal should write to Ed at 1958 Neil Ave., Columbus, OH 43210. . . . **Jeff Levinger** reports that his technical writing business is thriving — his son David Taylor Fox Levinger is learning to walk, talk, and bang the piano — that San Francisco is still the Levingers' favorite city — mind and body are being sustained by wife Lucretia's nutritional counseling, by Aikido, and by scientology processing and training — that his Apple and Intel computers are supporting his tech writing and software development teams — that he is planning to add some rooms to his house this spring — and finally that he would love to hear from old friends.

Frank Cocks is on a sabbatical visit to the Division of Applied Sciences at Harvard this semester, doing work with Professor William Paul on amorphous silicon for solar cells. . . . **Daniel Rie** was selected as second vice-president of the American National Bank and Trust Co. of Chicago. Dan will be senior investment strategist in the bank's research and strategy division. Prior to joining the bank last June he was on the finance faculty of the Wharton School of the University of Pennsylvania for ten years. Dan, his wife Cathryn, and their two sons, James and Michael, live in Wilmette. . . . Finally, **Theodore H. Myer** served as an expert panelist in a Bolt, Beranek, and Newman seminar on electronic mail last fall. The seminar, which dealt with computerbased message systems, traveled around to cities all over the country. Ted has directed BBN's research and development in electronic mail and office automation technology.

Well, thanks for your contributions to this space. Hope this material gives you a few minutes of reading pleasure this winter, almost eighteen years after we wintered together in Cambridge. Sitting here in the sunshine of the California winter it is hard to remember those Februarys and Marches filled with snowfall and cold winds. Were we tougher in those days? — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, CA 92715

64

Well, classmates, the mail has been quite light — only one class hero and three alumni fund envelopes with news. Let's hear from some of you!

Our class hero is **Robert Hinde**. Bob has just relocated back to New England from West Virginia. For the past eight years, he has been with Kaiser Aluminum and Chemical Corp. Recently Bob accepted the position of manager of technical services and engineering at the Kaiser plant in Portsmouth, R.I. His wife Marsha and their two children are just thrilled with the new area.

Now to the envelopes: **John Prather** continues with RCA, working on picture tube quality and reliability. He is also tracking engineering update courses in digital electronics and microprocessors. . . . **Bruce Herrick** is now professor and head of the Department of Economics, Washington and Lee University, Lexington, Va. . . . Our final envelope is from **Stanley Hallet**, professor of architecture at the Graduate School of Architecture at the University of Utah. He has just published a book, *Traditional Architecture of Afghanistan*. He designed a housing project

called "Quad" which won the AIA regional honor award. Recently the Hallets adopted a boy from Korea named Jong Soo Suh. Stanley's wife Judith is a filmmaker and TV producer for a mini-documentary show, *Extra*. I am two weeks late with this submission and hope you don't see a blank issue. In one of the next two or three columns, I'll try to catch up on what keeps us so busy. Thanx to Marlene for this column, and if anyone wants to pinch-hit as secretary for a while, write me and I'll say "WHEW!" and "THANK YOU!"Ciao! — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, MD 20854

65

What an upturn this month — several Alumni Fund envelopes and a genuine letter! The letter came from **Stan Wulf** who saw our column and ran into me at the inauguration (of President Gray, that is) and decided to write. Stan is now the president of the M.I.T. Club of New Bedford, Mass. He says they manage three meetings a year, which is not bad for a small club. The hit of last fall was their clambake. Stan says his firm, Brewer Engineering Laboratories, recently bought a line of torque sensors and he is manager of that line. He says the startup is challenging, frustrating, and fun. Stan also says he is enjoying the Cape Cod weather.

Stan Brown says his has been a year of expectations. After six years as assistant professor of surgery (bioengineering) at Dartmouth, he was expecting a promotion, but had also applied for a job at the University of California, Davis. Both came through and as of November 1, Stan was associate professor of bioengineering in orthopedics and director of Orthopedic Research at U.C. Stan says the prospects are very exciting.

Sanford Morganstein writes that he is director of engineering-switching at Rockwell-Wescom. Rockwell-Wescom is a designer and manufacturer of digital telephone switching equipment (PBXs and automatic call distributors). . . . **Dan Murphy** was active in WTBS (now WMBR) as an undergraduate, and I guess his interest has continued, as we got a newspaper clipping that he had sold station WCAS to a minority-controlled group for about $500,000. The station is located in Cambridge and had the distinction of being the lowest-powered in the state at 250 watts. . . . **Scotty MacVicar** received the Harold E. Lobdell Class of 1917 Distinguished Service Award for valuable support and inspiration to the Alumni Association. . . . **Art Bushkin** has been serving as special assistant for information policy in the National Telecommunications and Information Administration. He presented a paper on international information flow at a conference in Europe and is widely quoted in data processing publications here.

And that's this month. Better, but still not a great column. Please write. — **Steve Lipner**, Secretary, 6 Midland Rd., Wellesley, MA 02181

67

Jim Small has moved to the University of New Mexico in Albuquerque where he is associate professor of physics and does research in lasers and medical ultrasound. . . . Having retired from the Navy, Anne (Vallee) and **Terrill Williams** are building a home in the woods of northeast Washington state. . . . **Chuck Greene** has moved to Los Angeles. . . . In January 1980 **Victor Bermudez** married Catherine Bulmer of London, England. She is a Ph.D. electronic engineer working in integrated optics at the Naval Research Lab in Washington, D.C., where Victor is also employed. After a honeymoon in Jamaica, they settled in the Springfield, Vir., area.

John Gowdy proudly announces a new baby, Laura Beth Gowdy, born June 25, 1980. . . . **Mike Zuteck**, a consultant in wind energy, designed the blades on a 125-foot-diameter 200-kilowatt NASA/DOE machine at Kahuku, Oahu, Hawaii that was dedicated last July. The machine has averaged an outstanding 170 kilowatts after 2,000 hours of operation, and the wood/epoxy composite blades appear to be as good as steel, aluminum, or fiberglass. For sailing buffs, Mike finished second in the Tornado cat North Americans at Oshkosh, Wis., last summer. The regatta was low key after the Olympics boycott — but fun. — **Jim Swanson**, Secretary, 878 Hoffman Terrace, Los Altos, CA 94022

68

Those of us on the banks of the Potomac have generally survived the election which, for the second time in four years, we interpret as a rejection of Washington and everything it stands for. Perhaps it is time to move back to beantown?

We have one wedding and four births to report this month. First, **Leonard Horowitz** was married to Cheryl Beres on January 14, 1979, and they are living in Cleveland Heights, Ohio, where they run the restaurant Leonard opened in 1973. . . . The following note is included verbatim: "On December 14, 1979, co-implementers Radia Perlman, '73, and **Mike Speciner** announced delivery (only 3 days late) of Dawn Perlner, seven pounds, one ounce. In our rush to meet delivery schedule, the initial version lacks features such as a natural language interface. We will be working on adding such features over the next several years, aided by powerful learning heuristics included in the initial version." . . . **Steven Gamer** writes to announce the birth of a second son, Mark, in April 1979. . . . **John Niles** reports the birth of Karen on November 9, 1979. . . . Marla and **Richard Keys** report the birth of Stephanie in May 1979. Her sister Christine is now 6 . . . **Dan Asimov** has been teaching "spoiled rich girls" in the mathematics department at Smith College and thinking about topology, statistics, and causality. He would like to hear from classmates living near Smith or in the Boston area.

Howard Shaw has finally left the academic world and taken an engineering position with the Electronics System Division of the Bunker Ramo Corp. His main regret is that he should have come to Southern California ten years earlier. He is living in Thousand Oaks and invites his old buddies who may be passing through L.A. to visit. . . . Also out in sunny California is **Paul Forbes**, in San Clemente, who works for Bechtel Power Corp. on the San Onofre Nuclear Generating Station. He enjoys "the winter sun, beaches, low heating bills, and all the other amenities of 'California living.' " . . . In another warm area, **Richard Fox** is now manager of development engineering, Computer and Instrumentation Division, Westinghouse Electric Corp., Orlando, Fla. He is married to the former Joy Stein, and their daughter Karen is now 3 years old. . . . **Tom Murphy** has been promoted to chief of the Materials and Process Laboratory at Sikorsky Aircraft. . . . In May 1979, **Douglas Wilson** switched jobs from EG&G, Los Alamos, to Los Alamos Scientific Laboratory. He works in group X-1 designing targets to make CO_2 laser-driven inertial confinement fusion "a viable energy source for the next century." . . . Since October 1979, **Alan Dolmatch** has been a partner in Waltch Associates, a planning, development, and urban design firm.

Notice how all these people talk about the wonderful southwest; well, the northeast remains a popular place for classmates too! First, **Robert Phair** triumphantly announces, "We are back in the East!" He and Judy have left the University of Michigan and found a "marvelous house" in Towson, Md., convenient to his job as assistant professor of physiology at Johns Hopkins University. . . . Also nearby is **Robert Wyatt** who moved to Epping Forest in Annapolis where he works for CM, a construction management firm doing projects along the Atlantic seaboard. He would like to hear from friends passing through the Washington area. . . . Reena and **Dan Belin** are living in Middletown, Conn., with their sons, Jeremy, 7, and Steven, 4. Dan is in private practice in rheumatology and internal medicine. . . . **David Coomber** is working at Lincoln Lab designing and building digital circuitry for satellite communications. He reports that **John Capetanakis** has left Lincoln to join COMSAT in Washington.

That's all we have for this month, so keep those cards and letters coming, folks — **Gail** and **Mike Marcus**, 2207 Reddfield Dr., Falls Church, VA 22043

69

Well, not too much to report this month. Kristen and **Peter Zacharias**' second son, David, was born Christmas Eve, 1979, while in March this year Pam and **Joseph Lassiter**'s first child, Allison, was born. Joseph is working at Teradyne, Inc., in Boston as vice-president and division manager of the Manufacturing Systems Division. He and Pam invite any friends passing through or living in the area to give them a call.

John M. Brown, M.D., will be looking for a job in June when he finishes his residency in pathology at the University of Minnesota Hospital in Minneapolis.

After gaining tenure at the Department of Electrical Engineering at the University of Florida in the spring of 1980, **Michael E. Warren** left to form, with another faculty member, System Dynamics, Inc., an engineering research and consulting firm. Doing well and already growing, they're looking for additional sharp talent.

Another entrepreneur is **Donald T. Scholz** of rock group *Boston* fame and the class' second most successful member (see last issue). Don is now marketing his "Power Soak," the first of a series of electronic devices for professional musicians and recording studios which he has designed and will be manufacturing.

I'm behind schedule on my own projects but hope to have something to report next issue. Until then, send your notes to — **Robert K. Wiener**, Secretary, Box 27, M.I.T. Branch, Cambridge, MA 02139

70

James Pelegano writes that he is just beginning the practice of pediatrics in Connecticut; he and his spouse have three children. Now that they are back in the basic geographical area, close to M.I.T., he wants to get more involved in alumni activities. . . . **Mark A. Becker** is now manager of Software Development at TRT Data Products. Mark and Deborah have been married almost eleven years and have two children. They live in Fairfield, and Mark wonders whether or not the Class of '70 exists. . . . **Fred Campling** continues to be a Crown prosecutor in Hamilton, Ontario. His wife Cynthia is also a lawyer and has recently opened up a private practice in association with another woman lawyer. Fred and Cynthia are expecting their first child in March and have purchased a new house. . . . **James C. Liang** is an assistant professor of ophthalmology at the University of Illinois Eye and Ear Infirmary in Chicago. His wife Jocelyn (Wellesley, '70) comleted her Ph.D. in infrared astronomy at the University of Chicago.

Michael Prager has commenced the Ph.D. program in biological oceanography at the University of Rhode Island. He is working under an NSF graduate fellowship and gives his best wishes to all of his friends. . . . **Jim Brasunas** is continuing as an artist/blacksmith doing architectural iron work in the D.C./Baltimore area. He and his wife Lynne are expecting their third child and are commencing the building of a solar dreamhouse. . . . **Jim Caldwell** is living in Mountain View, Calif., with his wife Patricia. Both are electrical engineers, and Jim has completed his fourth year at Telesensory Systems, Inc., of Palo Alto, where he has developed a custom NMOS chip set, the programmable digital signal processor

for speech synthesis and other signal processing applications. However, his interests are currently shifting toward the software field.

Robert McKinley writes that it was good to see some of the classmates at the reunion, along with "little" **Joe Baron**. Robert is production manager at Teradyne, Inc., and enjoys the challenge of building state-of-the-art electronic tests systems. His 7-month-old daughter, "Maggie," educates both Robert and his wife Carol constantly. — **Robert O. Vegeler**, Secretary, Kennerk, Dumas, Burke, and Backs, 2120 Ft. Wayne National Bank Bldg., Ft. Wayne, IN 46802

71 10th Reunion

Jerry McCampbell is a new faculty member of the Long Trail School in Dorset, Vt. Jerry did advanced work in general science at Boston College and in math at the State University of New York. He will be teaching advanced biology, general science, chemistry and biology. . . . **Tom Sico**, staff attorney for the Ohio Bureau of Worker's Compensation, continues his private practice as well as his activities as member of the M.I.T. Educational Council, member of the Citizen Advisory Committee of the Mid-Ohio Regional Planning Commission, and counsel and member of the board of directors for a local computer firm. . . . **Richard Park** has recently completed renovation of an old city house into a beautiful modern dwelling. He thanks his former roommate **Bruce Smith** for exposing him to carpentry when they built a huge bookcase in their dormitory room at Senior House.

Dan Weinberg has moved to Washington, D.C., as an economist for the U.S. Department of Health and Human Services in the office of income security policy/research. . . . **Neil Ross** has started a medical practice devoted to diseases and surgery of the eye. His wife is also an opthalmologist, and they are partners in a new office they built in DeKalb, Ill. . . . **Matthew Becker** is to be congratulated: on December 20, 1979, his wife had a fine red-haired baby girl, Barbara Jessie, who joins their son Joshua. They live in Bethesda, Md., where Matthew is an anesthesiologist at Children's Hospital in the District of Columbia.

Technology Day, a traditional feature of reunion week, will be Friday, June 5. This year's program will focus on the automobile. We hope to see you there. — **Hal Moorman**, Secretary, P.O. Box 1808, Brenham, TX 77833

72

June was a big month for children in our class. **Riccardo DiCapua** reports that his wife Raquel delivered two twin boys, "Michael and Paul, M.I.T. Class of 2002, Department as yet unspecified." To make sure that the Institute would be ready for them he sent the then President Wiesner a note, too. . . . Judy and **Jack Carter** had their first, a girl named Joanne Jerstad. The baby was born in Scripps Hospital in La Jolla. Jack also noted that **Robert Schulte** is now president of Nixdorff-Lloyd Chain Co. in St. Louis. Jack and Judy were looking forward to a visit soon from Bob and his wife Susie.

Bradley C. Billetdeaux has completed his M.S. in operations research at Columbia and is using it at Caltex Petroleum Corp., where he has been employed ever since he left M.I.T. Brad is now working on an M.B.A. at N.Y.U. at night. He says that writing to the class notes is a great way to overcome inertia. Brad and his wife Susan see **Joel Bergman** once a year through Richard Sternberg, '74, who is now an M.I.T. based M.D. Last spring they visited Russel Perkins, '67, in Alexandra, Vir. **George Gudz** has spent three years working on the medical use of computers and four years working on space shuttle computers. He is very concerned about the mobility trade-off of various modes of transportation. . . . **Joe Auer** has been promoted to project engineer at Northrop Corp.'s Rolling Meadows, Ill., Defense Systems Division. He has been with the company for one year and will be responsible for developing support software in conjunction with U.S.A.F. avionics systems. . . . **Robert Lindgren** and his wife Sharon are living in Hinsdale, Ill. He has been named a managing principal of Dykeman Associates, where he serves as a primary consultant on employee benefit matters and an account manager for major corporations.

Doug Mahone left his position with M.I.T.'s architecture department to be director of energy and buildings research at TEA, Inc. He and his wife Lisa Heschong, M.Arch. '78, are expecting a baby in January to keep them company in the big, old house that they bought in Peterborough, N.H. They are both active in solar energy research and building design, enjoying the relatively relaxed life of a small town, and working at the same small interesting company Doug notes, "I feel like I've finally grown up." . . . Another classmate up in that part of the country is **Gail Thurmond** and her husband Joe. Gail recently celebrated her birthday by a rumored middle of the night drive from New Lebanon down to Boston for a fix of the city. She had been down to the Caribbean at the end of August for a fun-filled vacation. Another doctor, **Carter Noble** writes that he has been happily married for half a decade and is the parent of a beautiful, and only occasionally exasperating, 17-month-old daughter, Rachel Beth. He is currently completing two years in a rural southwestern Wisconsin community as a member of the National Health Service Corps, following a residency in family practice, and he is "thankful for God's many blessings."

Michael Cohen spent time with the Peace Corps in Peru as an agricultural planner after he left M.I.T. Then he traveled to parts unspecified. He spent the last three years as a manpower planner for two CETA agencies and would like to do research on quality of work life. He finds that the skills that he learned at M.I.T.are useful even though the specific knowledge is now obsolete. . . . **Lawrence Cohen** reports that he is a member of the technical staff at TRW Defense and Space Systems Group, Redondo Beach, Calif.

I saw **John Gunther** in Alaska in Septmber. He took time off from his busy work as a consulting engineer in a company he recently started, ErgsCo, to show me around the state. We managed to go backpacking up in the Brooks Range late enough in the year that we avoided the mosquitoes and saw great displays of the Northern lights! We saw lots of bears from the safety of John's vehicle in Mt. McKinley National Park and managed to sneak up close to numerous seals on the icebergs floating in Glacier Bay. It was a quick, spontaneously planned trip, since I had to return to practicing law, and John had to finish a job before taking off for a five-week vacation in Germany and other parts of Europe. While I was away, I got a call from a friend of **Caroline Pass** '73. Unfortunately her friend was gone by the time I returned, so I have no further news of her work in Africa. **Kathy Kram Dobkin** has moved to Boston and is teaching at B.U.

Please keep your notes coming. For now I am trying to start my Christmas shopping (I am a slow shopper). I realize that by the time you read this, winter will be half over and I will have been to China and back — **Wendy Elaine Erb**, Secretary, 531 Main St., Apt. 714, New York, NY 10044

73

Greetings from the yonlands. Y'all have deluged us with mail this month, so here goes. Old next-door neighbor has moved to London, England, where he is involved in construction projects in the Middle East. . . . MFC (most faithful correspondent) **Doug Levene** is now in his third year of law school, after which he will clerk for a year for Judge J.E. Lombard on the U.S. Court of Appeals in New York; then will join Cleary, Gottlieb, Steen and Hamilton, also of New York. Doug is still single (perhaps connected) and spends his spare time at midnight shows of the *Rocky Horror Picture Show*. . . . Another VII-A friend, **Karl Gallegos**, writes as having graduated from Harvard Medical School in 1977, and after turns at Roosevelt and Columbia Presbyterian in New York, is now at C-P as an orthopedic surgical resident.

Sic transit gloria medicum; which is Esperanto for I'm sic (sic) of reading about all them doctors. Somehow we got a bunch of 'em this month, including **Michael Cedars**, who will finish his plastic surgery residency at U.C.L.A. in 1984. And . . . **Steven Nadler**, who is chief medical resident at Royal Victoria in Montreal P.Q., planning a fellowship in nephrology. . . . **Joel Franck** was a graduate fellow in neurophysiology at Rockefeller University, whereupon he took an M.D. at Yale, resided in surgery at Upstate Medical Center in Syracuse and is now there again as resident in neurosurgery.

Tom Lydon is in charge of computer simulations for Sunsearch, Inc., in Guilford, Ct., a solar research company. He is also teaching computer energy analysis part-time at Yale School of Architecture. First child Mary Elizabeth ('02), born September 29 and mama Mary Paula are doing fine. . . . **Scott Davidson** finished his Ph.D. in computer science. He's working for Western Electric in Princeton, N.J., which he swears is much nicer than the Lousiana swamp. Wife Tish and he have been married two and one-half years now.

Tony Scandora is working with Science Applications, Inc., in Chicago. They bleed the government for lots of money in consulting fees. And Ruth and I are enjoying life back South with kids. Ahhhhhhh. — **Robert M. O. Sutton**, Class Secretary, 819 Buckingham Ct., Warrenton, VA 22186

74

Here now the news. We are currently experiencing the "early new year news slump." Some brave classmates of ours, however, continue to break with tradition and have sent in some choice morsels for your perfunctory consumption.

Back in the hills of the San Francisco Peninsula (soon to be an island), **S. Jeffrey Rosner** rides his bicycle wildly and plots strategy for winning the next century race (100-mile cycling event) in the northern California hills. During the week, he is a mild-mannered designer of mass spectrometers at the Hewlett-Packard Scientific Instruments Division. Well, Jeff, just keep spinning along . . . doo-dah doo-dah.

John Nickerson writes: "I recently received my Ph.D. from the University of Texas in cell biology and human genetics. My wife and I are moving to Bethesda, Md., where I will be a staff fellow in the Laboratory of Molecular Genetics at the National Institutes of Health."

Edward J. Kronenberger III and his wife Susan are in the process of moving around Houston while Shell Oil decides where to settle. Susan is a geophycisist for Shell, and Ed works for the Dow Chemical Co., in Freeport, Tex. Besides home maintenance and planning for a new home, they spend time backpacking. Last summer they visited Glacier National Park where they saw traces of ash from Mt. St. Helens on the glaciers and permanent snow banks. I still think the entire mountain is going to explode. But then I never thought that an actor would be elected president.

Now we get into the New England segment of the notes. **Stephen Blythe** is presently a student and "visiting lecturer" in nutrition at the New England College of Osteopathic Medicine. As a result of the time he spent living in Central America last year, he has been doing some public speaking on the political/human rights situation in some of the countries in the region. I don't think any of us in the great ole' U.S.A. have much to worry about now that Ronnie is in charge. Yep, he's gonna clean up everything, get our canal back, and make Mexico give us the oil that we deserve.

Laurence Reece is beginning his third year as a

lawyer with the Boston firm of Nutter, McClennen, and Fish. He says, "Although litigation bears little relation to 8.01 problem sets, I find it exciting and challenging." In September, he travelled to South Bend, Ind., to visit **David L. Vance**. The report is that he is married, employed by an environmental consulting firm, and enjoying the relaxed lifestyle of the Midwest. So that's where the Midwest is!

I want to recommend to all of you that you visit the Class of '74 Shrine at the corner of Briggs Field soon. The drinking fountain donated by our class is a humble token of our appreciation for the opportunity of intramural sports in our undergraduate lives.

I want to encourage those of you that have the cranial capacity to read between the lines and find me a little out of my mind to write and let me know. You do not have to send money to get into the class notes. I will, however, accept coupons and stamps. Have a nice administration. — Cosecretaries: **Jim Gokhale**, 12 Pond Lane No. 54, Arlington, MA 02174 and **Lionel Goulet**, 34 Tremlett Sq., Dorchester, MA 02124

76 — 5th Reunion

Zachary Levine is now at the University of California at Berkeley in physics. He received his M.S. in physics from the University of Pennsylvania last June. "I have many fond memories of Penn and Philly. I continue my drive toward over education in seeking the almighty Ph.D. in a couple of years. . . . I saw **Cliff Ragsdale** here recently. He is going to Tech (again) in neurophysiology.

From **Clark Baker**: ". . . finally received my S.M. in electrical engineering in June. Miriam Alexander and I were married in August in the M.I.T. chapel. Following graduation, I accepted a research staff position at the M.I.T. Laboratory for Computer Science. Currently I am developing software tools to aid in the design of very large scale integrated (VLSI) circuits (microprocessors, memories, etc.)." . . . **Richard Radville** is "currently staff architect for the Architects Collaborative, Inc., in Cambridge. Involved in design of a large critical care hospital in Pittsburgh, and an insurance company headquartered in Hartford, Conn." . . . **Stephen Dodd** has been promoted to assistant plant manager of the Davay Co. and has been transferred to Downingtown, Penn. The Davey Co. is a manufacturer of bindersboard, used in the bookbinding industry. . . . **Jordan Wouk** sends word that he now has a son, Edward Howard, born at the end of July. Jordan is now a project supervisor in computer systems development with Guardian Life Insurance.

David Leighton is now working in Saudi Arabia for ARAMCO as a systems analyst. "My wife Beverly is accompanying me. We celebrated our third anniversary June 4." . . . **R. C. Lijana** sends a laconic message: "M.S. (chemical engineering), 1978, from the University of California/Berkeley. Currently employed by Procter and Gamble working with pharmaceutical products." . . . **Christopher Roberts** graduated from the University of Virginia Law School in 1978 and has been working for Chadbourne, Parke, Whiteside and Wolfe, a New York City law firm, since September, 1978. He currently lives in Manhattan. . . . **Fred Jones** is on the technical staff in the Laser and Optics Department of the Aerospace Corp. in El Segundo, Calif. Fred has also been doing some college recruiting for them as well as research.

Your secretary continues in his fondness for The Horsemen of the Apocalypse. This time, the rider I have been rooting for is War. (The Iran/Iraq war has done some marvelous things for me in home heating oil futures.) It is a peculiar business, futures trading. Every night your secretary goes to sleep knowing that if he awakens to the news of another catastrophe, it can only be beneficial vis-a-vis his markets. On this cheerful note, *write*! — **Arthur J. Carp**, Secretary, Sandro Rohstoff, Inc., 1 World Trade Center, Suite 9853, New York, NY 10048

79

Salutations from beautiful West Philadelphia. Lots of news this month for all you gossip-starved class members!

Paul Hoffman, writing from "scenic Central Square", reports that life is good. Paul is the customer service rep for a company in Harvard Square "with the incredibly creative name of 'Software House.' Lotsa fun. I mean, what else is there to do with degrees in chemistry and political science?!" . . . Meanwhile, over in Oxford, **Carolyn Farley Maricq** is working of a research master's degree at the Oxford Centre for Management Studies, while husband Matti, Ph.D. '79, is a post-doc at the Physical Chemistry Lab. Until last April, the Maricqs were living in "beautiful Boulder, Colo., where Carolyn commuted to her job in Denver as a research associate with Mathematica Policy Research, and Matti was a research associate at the University of Colorado at Boulder. "We really loved being right next to the mountains. We got a lot of pleasure from hiking, skiing, and bicycling. The weather at Oxford was a shock after Boulder, and so, too, was the educational system! But now that we've accepted the differences, we are enjoying England." Carolyn is now keeping herself fit by rowing women's crew at Oxford's Wolfson College. Carolyn and Matti had a great time cycling through France and Switzerland this summer.

Brad Brewster reports that he, **Greg Floro**, and **Clay Funkhouser** are all second-year students at the Kellogg Graduate School of Management at Northwestern University in Chicago, and **Bob Cornick** is working for Procter and Gamble in Cincinnati. Brad wrapped up his summer at Exxon in New York City in time for his September 12 wedding to Trish Doherty of Arlington, Mass. Congratulations! . . . More students: **Gail Kaiser** is in her second year of computer science study at Carnegie-Mellon in Pittsburgh. "I'm now a Hertz Fellow, so I'm paid reasonable money just to go to school. My husband, **David Dill**, recently took a huge cut in pay when he was 'promoted' from research programmer to first-year grad student, but he's quite pleased anyway!" . . . **Guy Emanuel**, in his second year at Cornell Medical College in New York City, is president of Cornell's chapter of the Student National Medical Association. . . . **William Ericson** is also in medical school, having spent his summer working on medical education programs at Mass. General Hospital. At last word, he anticipated being there for nine weeks in the spring as well. Bill recently took up fly fishing, and planned to spend his weekends this winter on the local ski patrol. . . . **Bruce Gage** is back in his hometown, Seattle, at the University of Washington Medical School.

Meredith Warshaw writes that she is "currently working in a community residence in Waltham for deaf or non-verbal retarded people. The work is difficult; I haven't decided how I like it yet. Meanwhile, my roommates and I got condo'd out of Cambridge, so now I get to see the Institute from the other side of the Harvard Bridge!" . . . Our man in uniform, **Norman Guivens**, completed nuclear power training last August and is now a qualified nuclear power officer. Norman was most recently assigned as a student at Surface Warfare Officer School (SWOS) in Coronado, Calif. He was planning to leave SWOS is December and, after two weeks of leave, report for duty in January on board the *U.S.S. Long Beach* at Bremerton, Wash. . . . **Arthur S. A. Liu** is "still working and living well in the Boston area. This year I am also a special graduate student at M.I.T." . . . **Raphael Vermeir** reports tersely that he is a "naval architect and marine engineer." . . . **Gregory Pai**, equally terse, is an economist with the Environmental and Nonmarket Economics Division of the Department of Commerce's Bureau of Economic Analysis.

This line is for **Michael Kass**, who thinks that my column contains too many exclamation points: !!!!!!!!!!!!!!!!!

August 16 was the magic date for **Margaret Wong** and Nelson Chen (brother of **Ginny Chen**), who were married in the M.I.T. Chapel and then celebrated with a reception in the Spinnaker Lounge of the Hyatt Regency. Present were **Joan Sienkiewicz**, **Pei-ti Tung**, and **Susan Lau**. . . . **Keith Reid**, whom readers of this space will recall is a sales engineer for Dupont, reports, "As I make my rounds in New England, I find that many of my customers are former Beavers. This, I must say, doesn't *hurt* business!" Keith is now involved with three music groups at the local church, "two of which are singing, and the third — piano, flugelhorn, and voice, doing all originals. Will be copyrighting four songs shortly!" Keith's "Fantastic Four" seems to be all over the country: **Cornell Pearcy** is here in Philly at Jefferson Medical School, and **Nola Hylton** is studying physics at Stanford. **Adonis Neblett** is out in Seattle at the University of Washington School of Law, pursuing what he calls a "degree in social engineering — that is, a J.D.!", and missing Boston.

Ann Michon breezed into Philadelphia recently from California. Ann makes the hour-long commute each day from her home in Cupertino (ten minutes from Stanford) to her job in marketing development with Tymshare in San Francisco. Ann was here in the City of Brotherly Love (talk about misnomers!) to lead a seminar for eastern seaboard Tymshare employees. . . . After staying on an extra year at the 'Tute for a master's, **Hy Tran** recently turned up in this area. He is working for Hewlett-Packard in Avondale, Penn., and living in Kennett Square, Penn., home of the beautiful Longwood Gardens. . . . **Debbie Meyerson** dropped a note last August from "the mighty Maroon Bells, right around the corner from Aspen, Colo. Roby Rosen, '78, John Marcou, '78, **John Cochrane**, and I are squaring off with the forces of Mother Nature, here in the Rocky Mountains. Yesterday Roby and I went fishing and caught numerous forms of wildlife, while John and John blazed new trails in the unnamed peaks!" . . . **Gordon Haff** sent me a copy of the *Dartmouth Review*, a new paper of which he is one of the founders and the senior vice-president. Gordon is studying at Dartmouth's Thayer School of Engineering. The *Dartmouth Review* is complete with "The Last Word,"courtesy of Mr. Haff, adorning the last page! The alumni-financed paper, which was created to counteract a "liberal trend" at Dartmouth, has been a subject of great controversy since its appearance last June. How refreshing to see a class member out there making a splash! (As I always say, if you can't be famous, be infamous!)

Back to the books! Write soon. — **Sharon Lowenheim**, Secretary, 3600 Chestnut St., Box 1166, Philadelphia, PA 19104

80

It's always nice to start off the column with some good news. In this case, the good news is the engagement of **Lucia Chen** and Matt Markert. The wedding is being planned for this June. Congratulations, and let us hear how the wedding turns out!

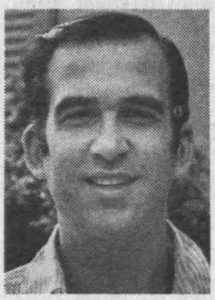
Davis Pan is working on an electrical engineering coop program with Bell Labs in New Jersey. . . . **Tony Parham**, having started work for Bell, was sent to the University of Southern California to get a M.S. in computer science. . . . Also working on a M.S. degree is **Thomas Sparks**. Tom is at Northwestern University in Evanston, Ill., in materials science and engineering.

My Class of '79 colleague has spied a couple of our classmates lurking around the University of Pennsylvania in Philadelphia. **Susan Shakin** is attending the medical school there. . . . **Leonard Sax** is enrolled in the Graduate School of Education at the University of Pennsylvania.

Another lame month for news, I'm afraid. Next month: news from our West Coast correspondant! — **Ken Turkewitz**, Secretary, 241 Lexington St., Bldg. 15, Apt. 2D, Woburn, MA 01801

Puzzle Corner
Allan J. Gottlieb

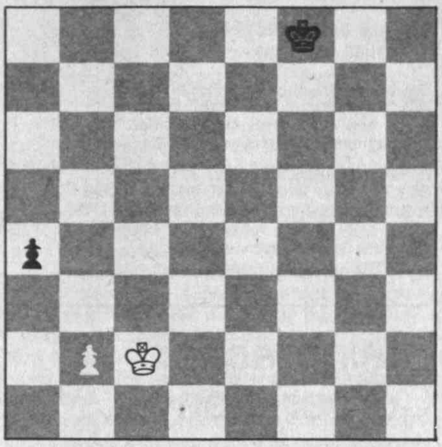
The Spider and the Fly



Allan Gottlieb is associate professor of mathematics at York College of the City University of New York; he studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y. 11451.

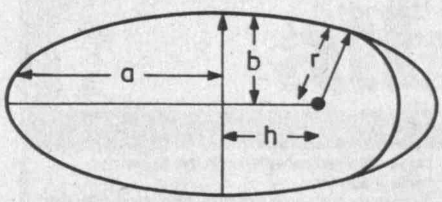
I have a story to tell. This year I have been working on the ultracomputer project at the Courant Institute of New York University (an ultracomputer is our mathematical model for a very-large-scale parallel computer), and every Thursday the faculty members go out for an ultralunch. Those of you familiar with Greenwich Village will not be surprised to hear that we are often leafletted as we walk. One Thursday a young man handed me a sheet of paper which I folded up to read later as we were talking a little shop. I was the only one in our group to receive the handout, so one of my colleagues asked me about it. Well, it turned out to be an announcement of a fraternity party, and I must have been the only one who looked young enough to be eligible. Of course I sort of floated through lunch; indeed, the event made my whole week. When I later recounted this tale to some of the graduate students, I was the object of some skepticism by a passing faculty member: Was the fraternity seeking youth or immaturity? Who knows?

FEB 1 We begin with a chess problem that Bob Kimble attributes to Robert Breiger: Given the diagram below, White is to move and win.



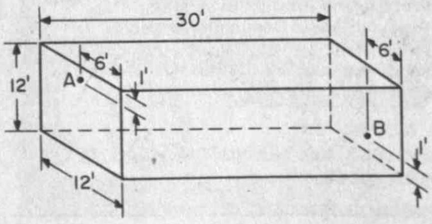
FEB 2 Next we have a number theory problem from Jerome Taylor: Does every prime number above 5 divide evenly into a oneless string of 1s? For example, 7 divides 111,111; 11 divides 1,111,111,111; and 13 divides 111,111,111,111. Does 17 divide 1,111,111,111,111,111? 19 divide 18 1s? Etc?

FEB 3 A geometry problem from Winslow Hartford, who writes: My daughter and son-in-law, who exhibit minerals, want to design a display shelf in the shape of an ellipse truncated by two circular arcs tangent to it, as illustrated.



1. Derive a general expression for the radius of the tangent circle in terms of the semi-axes of the ellipse, a and b, and the coordinate of the center of the circle h.
2. The largest circle that can be inscribed for a given ellipse has radius b. Show that there is also a smallest circle and find its radius and center in terms of a and b.

FEB 4 Will Lidell has sent us a copy of "the spider and the fly problem" that first appeared in *Link-Belt News* in August, 1935. Point A represents a spider and point B a fly, on opposite walls of a room. What is the length of the shortest path the spider can fol-



low to reach the fly? (The spider can only travel on solid surfaces — i.e., the walls, floor, and ceiling.)

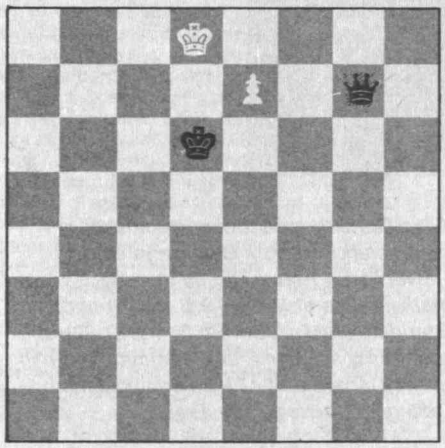
FEB 5 We end with a problem from J. L. Friedman that Calibron Products, Inc., printed in Technology Review in 1938: A rectangular leaded glass window was made up of 12 rectangular pieces of glass having the following dimensions in inches:

3 × 10	10 × 12
4 × 20	10 × 15
5 × 7	10 × 15
5 × 20	10 × 20
7 × 23	13 × 15
8 × 23	13 × 15

What were the proportions of the window, and how were the pieces of glass arranged? (There were no gaps or overlappings.)

Speed Department

FEB SD 1 A chess speed problem from Peter Sorant, a dorm-mate of mine back at M.I.T.:
White is to move and draw.



FEB SD 2 This cryptarithmetic quicky is from Winthrop Leeds: Replace each letter by a unique digit so that a valid multiplication and addition is obtained. Only the nine digits may be used, and *zero is excluded.*

```
  U P
× A
 D O
-R E
 M I
```

Solutions

OCT 1 South is on lead with hearts trump and is to take six of the remaining seven tricks against any defense:

North: ♠8 3 ♥J 5 ♦6 4 2 ♣—

West: ♠J 7 6 ♥9 ♦9 5 ♣J

East: ♠5 ♥6 ♦Q 10 ♣K 8 4

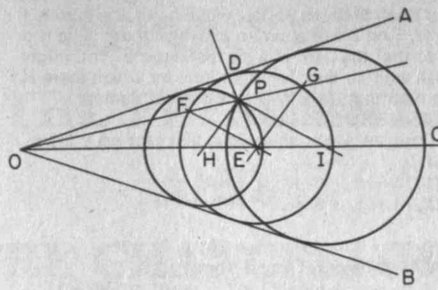
South: ♠K 4 ♥— ♦A J ♣Q 7 6

John Boynton sent us the following plan of attack:
The only workable initial lead is to ruff a club in dummy. Of the possible second leads (from dummy), only the trump lead carries; but the slough in South is the interesting maneuver. By discarding the ♠K, declarer effectively unblocks his hand so he will be later locked in dummy where the good tricks are. Thus, after ruffing the initial club and drawing a round of trump (discarding the ♠K), declarer takes the diamond finesse and plays the remaining diamond (winning both tricks, depending on East's play). Declarer is now in South with only a small spade and the clubs. A spade lead now either wins in dummy, if West ducks, or loses to the ♠J, whereupon West leads to the promoted ♠8 in dummy. Finally, the good diamond becomes the sixth trick (two hearts, three diamonds, and a spade).

Also solved by George Holderness, Doug Van Patter, Al Salish, William Katz, R. Bart, Matthew Fountain, John Woolston, Chester Claff, Robert Park, Winslow Hartford, Manuel Matnick, Dorothy Bryant, Smith Turner, and the proposer, Emmet Duffy.

OCT 2 Given an angle and a point within an angle. Using only a straightedge and compass, construct the two circles that pass through the point and are tangent to the lines forming the sides of the angle.

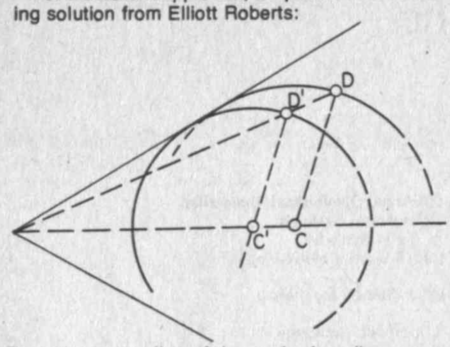
Emmet Duffy (by coincidence the proposer of the last problem) has sent us several carefully drawn constructions for this geometry problem, as well as noting a connection between this problem and **1978 J/J 5.** I print below the solution that he prefers:
Referring to the drawing, let the vertex be O, the sides OA and OB, and the point P. Construct the bisector OC of angle AOB. Through point P, construct a line perpendicular to OA, intersecting OA at D and OC at E. With ED as a radius and E as a center, draw a circle tangent to OA at D and also tangent to line OB. Draw a straight line through O



and P intersecting the circle at F and G. Draw EF and EG. After drawing EF and EG, simply draw through point P lines parallel to EF and EG, intersecting OC at H and I. With H as a center and HP as a radius and I as a center and IP as a radius, draw the desired circles.

The following artifice eliminates much geometry. Assume that a photograph of the drawing has been made and a positive transparency is placed in an enlarger-reducer. Assume a projection is placed over the original drawing keeping point O and the lines of the angle in the projection coincident with the original drawing. As the projection is enlarged, point F in the projection can be made to coincide with point P of original drawing, and point E of the projection will move to the right along line OC. Mark this point as I on original drawing. It will be the center of the desired large circle, the radius of which will be the distance IP. In a similar manner if the projection is reduced until point G of the projection coincides with point P of original drawing, point E of the projection will move left along line OC. Mark this position as point H on original drawing. It will be the center of the desired small circle and radius will be distance HP. Points I and H can be found geometrically using Proposition IX of Book III: if a line is drawn through two sides of a triangle parallel to the third side, it divides the sides proportionally. Construction is as follows: draw a line through P, parallel to EF and intersecting OC at I, and draw a line through P, parallel to EG and intersecting OC at H. Then OP/OF = OI/OE; OP/OG = OH/OE; and I and H are the centers and IP and HP are the radii of the desired circles.

For a different approach, we present the following solution from Elliott Roberts:



Draw the center line of the angle. Inscribe a random circle with its center at C′. Find P′ on a radial line from the vertex of the angle. Draw P′C′. Draw PC parallel thereto. C is the center of one circle. Proceed similarly for the other circle.

Also solved by D. Freeman, Harry Maynard, Matthew Fountain, William Rapp, John Woolston, John Joseph, Raymond Gaillard, R. Bart, Harry Zaremba, Norman Wickstrand, Richard Hess, John Gray and J. Younkin, and the proposer, Jon Davis.

OCT 3 Consider summing each of the following eight arithmetic progressions:

$1 + 2 + 3 + \ldots + n$
$1 + 3 + 5 + \ldots + (2n - 1)$
$1 + 4 + 7 + \ldots + (3n - 2)$
$1 + 5 + 9 + \ldots + (4n - 3)$
$1 + 6 + 11 + \ldots + (5n - 4)$
$1 + 7 + 13 + \ldots + (6n - 5)$
$1 + 8 + 15 + \ldots + (7n - 6)$
$1 + 9 + 17 + \ldots + (8n - 7)$

For each of these series, when $n = 1$ the sum is $1 = 1^2$. Find the one series for which there is no $n > 1$ so that the sum is a perfect square. You might then want to find the two series for which there is an n so that the sum is the perfect number 2305843008139952128.

Douglas Szper solved the first part as follows: Let

$S(1, n) = 1 + 2 + \ldots + n$
$S(2, n) = 1 + 3 + \ldots + (2n - 1)$
. .
$S(8, n) = 1 + 9 + \ldots + (8n - 7)$

Then we have for any d from 1 to 8

$$S(d, n) = 1 + (d + 1) + \ldots + ((n - 1)d + 1)$$
$$= (1 + 1 + \ldots + 1) + (d + 2d + \ldots + (n - 1)d)$$
$$= n + n(n - 1)d/2$$

Thus

$S(1, 8) = 6^2$
$S(2, 2) = 2^2$
$S(3, 81) = 99^2$
$S(4, 25) = 35^2$
$S(5, 6) = 6^2$
$S(6, 9) = 15^2$
$S(7, 2) = 3^2$

and hence the first seven series all yield perfect squares. Now assume that there is an n such that $S(8, n)$ is a perfect square, say k^2. Then $4n^2 - 3n - k^2 = 0$.

So for n to be integral, $9 + 16k^2$ must be a perfect square, say d^2, and thus $d^2 - (4k)^2 = 9$. But no two perfect squares differ by 9.

Frank Carbin found one series that gave the perfect number desired. The Euclid-Euler theorem states that any even perfect number equals $2^{P-1}(2^P - 1)$, so it seems prudent to try to factor our perfect number in that fashion. Indeed, it is equal to $2^{30}(2^{31} - 1)$, or

$$2^{61} - 2^{30} = 2.2^{60} - 2^{30}$$
$$= 2n^2 - n, \text{ for } n = 2^{30}.$$

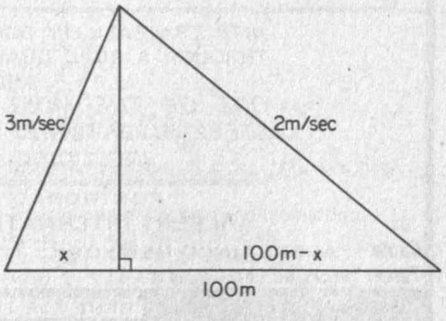
But $2n^2 - n = S(4, n)$, so the fourth series gives the number sought.

Finally, Matthew Fountain noted that series 1 gives all the partial sums that series 4 does, since $1 + 5 + 9 + \ldots = 1 + (2 + 3) + (4 + 5) + \ldots$

Also solved by Neil Hopkins, Edwin McMillan, Jim Landau, Harry Zaremba, Steve Feldman, Winslow Hartford, Emmet Duffy, D. Friedman, Richard Hess, and R. Bart.

OCT 4 A steam railroad runs parallel to a river 100 meters away. Unfortunately, the engine boiler has developed a small leak so that there is a loss of one liter of water per second for every ten meters per second the train travels. The conductor is dispatched to refill the train's water reservoir using a ten-liter bucket. He can walk three meters per second with the empty bucket but only two meters per second with the full bucket. What is the fastest constant rate of travel that the train can maintain under these circumstances?

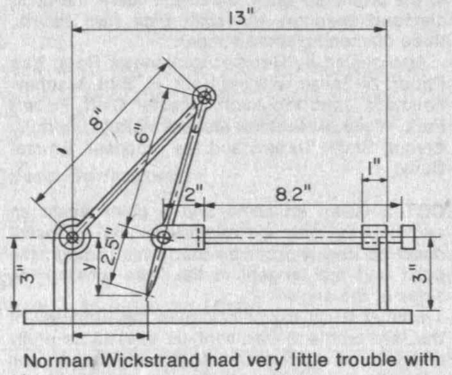
The following solution is from Winslow Hartford:



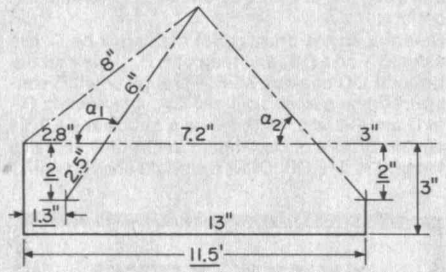
To keep the train moving at the fastest possible speed, it must use up 10 liters of water in the time required for the conductor to go to the river and return with 10 more liters. Since the train uses 1 liter per second for each 10 meters per second of speed, the train will travel 100 meters to use the 10 liters. The total time for the conductor is thus $(\sqrt{10,000 + x^2})/3 + [\sqrt{10000 - (100 - x)^2}]/2$. By setting the derivative equal to zero and solving for x, we find a minimum of 92.708 seconds for $x = 62.320$ meters. Thus the train travels 100 meters in 92.708 seconds or 1.07865 meters per second, and the conductor travels 224.69 meters in the same time — true dedication.

Also solved by Harry Zaremba, Marlon Weiss, Victor Newton, Douglas Szper, R. Bart, Steve Feldman, Richard Kruger, Smith Turner, Matthew Fountain, Robert Park, D. Freeman, Richard Hess, and Jim Landau.

OCT 5 Find the values of x and y at the two extreme positions for the device shown below.



Norman Wickstrand had very little trouble with this one:



$$\cos \alpha_1 = \frac{2.8^2 + 6^2 - 8^2}{2 \cdot 2.8 \cdot 6} = -.6 = \cos 126.87°$$

$x_1 = 2.8 + 2.5 \cos \alpha_1 = 1.3''$

$y_1 = 2.5 \sin \alpha_1 = 2''$.

$$\cos \alpha_2 = \frac{10^2 + 6^2 - 8^2}{2 \cdot 10 \cdot 6} = .6 = \cos 53.13°$$

$x_2 = 10 + 2.5 \cos \alpha_2 = 11.5''$

$y_2 = 2.5 \sin \alpha_2 = 2''$.

Also solved by Harry Zaremba, Douglas Szper, Frank Carbin, Avi Ornstein, R. Bart, Emmet Duffy, Edward Dawson, Richard Hess, Michael Jung, and the proposer, L. Steigler.

Better Late Than Never

MAY 3 Dan Pratt offers "amyotonia" and "oidia."
J/J 3 H. Moore has responded.
A/S 3 Mary Lindenberg has submitted a construction.
A/S 4 Robert Lutton and Dennis Sandow have responded.
A/S 5 Robert Lutton has responded.

Proposer's Solutions to Speed Problems

FEB SD 1 P—K8 promoting to a Knight (making a Queen loses to Q—QB2).

FEB SD 2

$$\begin{array}{r} 17 \\ \times\ 4 \\ \hline 68 \\ +25 \\ \hline 93 \end{array}$$

REPORT OF THE PRESIDENT AND THE CHANCELLOR

FOR THE ACADEMIC YEAR

1979–1980

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Our report for 1980 is a challenging task, for it was a most exciting, eventful, and in many ways, difficult year. It was, first, a time of transition for the Institute. The Chancellor was elected the fourteenth President of MIT and Francis E. Low, the Karl Taylor Compton Professor of Physics, was appointed to succeed Provost Walter A. Rosenblith as the principal academic officer of the Institute. The year also saw the highly successful completion of the Leadership Campaign and a return to the steady state of fund-raising efforts. And it was a year when the forces of the economy and the social realm continued to exert their pressure on the university — and on choices facing both institutions and individuals.

For President-elect Paul Gray and the new Provost, Francis Low, this is a moment of stocktaking and planning. For Walter Rosenblith and Jerome Wiesner, it is a moment for reflection as they look back on more than 30 years of involvement in the academic affairs of MIT and rejoin the ranks of the teaching faculty.

The transition to the new leadership is greatly facilitated by the continuity provided by the Chairman of the Corporation, Howard W. Johnson, and especially by the fact that for almost three years the Chancellor has been responsible for the daily management of the Institute while the President concentrated his efforts on the Leadership Campaign.

The academic programs, buoyed by the proceeds of the Leadership Campaign, continued to exhibit exhilarating vitality: the traditional disciplines evolving in search of and in response to new knowledge and new challenges, and the emerging programs continuing their development and their search for their appropriate place on the intellectual map of the Institute.

The excitement and vigor which attend this stretching of our intellectual reach is tempered, however, by the economic conditions affecting society as a whole. Even with the new support provided by the Leadership Campaign and the continued growth of the Industrial Liaison Program, MIT, like most other institutions in the society, had a hard time financially in the past year. While inflation and energy costs soared, the administration did its utmost to moderate the impact of "double-digit" inflation on all its members. Nonetheless, our faculty and staff continue to feel the decline in the purchasing power of their salaries and wages, while our students and their families dig deeper to meet the necessary, though painful, increases in tuition and other college costs. At the year's end, with the help of strenuous efforts at controlling costs and raising funds, the Institute closed its books with a small positive balance. To maintain this position in the years ahead will continue to be a challenge to the creative efforts of all — administrators, faculty, staff, alumni, and trustees.

We have mentioned the influence of the economy on individual, as well as institutional circumstances. For undergraduate students, the pressures of the job market have led them to enroll in departments which appear to offer more immediate or practical career opportunities. Record numbers of students enrolled in many of the engineering departments and in the Sloan School of Management, creating overloads on the teaching staff and facilities which required special remedies. At the same time, other departments faced the need to accommodate, at least temporarily, smaller teaching loads.

Graduate school enrollment patterns, on the other hand, were quite different. Where problems existed, they were due in large measure to the shortage of financial support in the form of research and teaching assistantships. Parenthetically, we note with real concern the fact that the shortage in housing for graduate students has become a major problem for the Institute and its students.

Beyond the walls of the university, in a world whose momentum and values are so closely integrated with the history and future of MIT, the year just past marked the beginning of a new decade — one almost universally expected to be a period of diminished affluence and falling expectations. It is a decade whose outcome will, to a considerable degree, be affected by the ability to create and put to work new knowledge and new technologies, on the one hand, and by society's success in assimilating and controlling the social

Jim Snyder

impact of technologies, old and new. It will also be a decade in which learning how to better manage an industrial society in an interdependent, turbulent world will be a major challenge, perhaps the dominant one. These are not new problems, but because most of the major issues confronting the world — such as providing adequate energy and food, protecting the environment, limiting population growth, controlling nuclear weapons, bolstering industrial productivity — tend to grow exponentially, the problems of the previous decade tend to become the crises of the next. No doubt the uniqueness of the next decade lies in the number of areas in which exponential growth makes decisive actions mandatory — and requires new modes of thinking, new ways of managing traditional enterprises, new technologies, and wholly new disciplines. Fortunately, for MIT, the problem is not lack of ideas and possible solutions to these challenges. We must, however, continually search for the resources, the time, and the money to explore them all.

More than three decades ago, the United States emerged from World War II confident in its power, hopeful about its ability to employ technology for the common good, and optimistic about its ability to lead the world in a search for a higher standard of living and an equitable life for all. In those three decades there have been several violent swings of mood, the lows bordering on public depressions, as successes and disappointments in some major aspect of national life have captured public attention — space exploration; medical advances; the Vietnam War; the arms race; the deteriorating environment; the emergence, and loss, of leadership in important areas; inflation; and so forth. During several of these swings, science and technology have come under attack as one of the main causes of the problem. Today, there may be some more general recognition that the provident use of new technologies is essential to the amelioration of the multi-crises of our times. Yet, the fear of the unanticipated consequences of large-scale technologies remains.

Over the years, the MIT administration has made a special effort to understand and publicly explain the issues and to serve as a spokesman for the scientific and technical community, while attempting to enhance the related teaching and research efforts of the faculty and the student body. Much of the response by the faculty and administration to fundamental issues forged from the interaction of science, technology, and society has taken the form of developing new teaching and research activities. This is a continuing process, as vital today as at any time in the history of our nation.

THE LEADERSHIP CAMPAIGN

In 1975, stating the goals of the Leadership Campaign, we said:

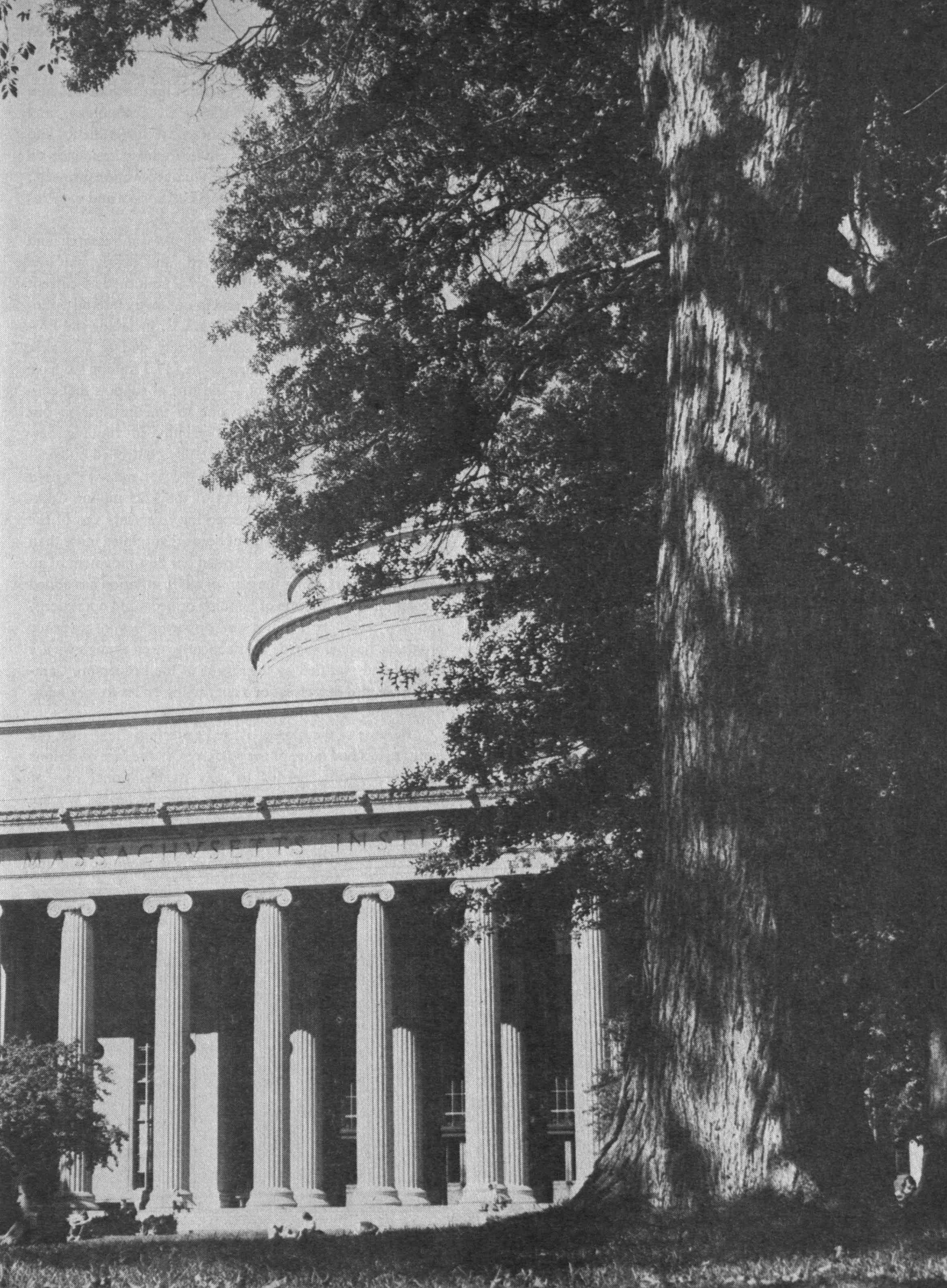
Today the Institute is unique in the extent of its teaching and research programs that encompass many areas of universal concern: energy, health care, industrial productivity, housing, the urban scene, economics, materials, communications, computers and computation, food and nutrition, education, arms control, international relations, the management of technology, natural resources, and environmental protection. These are supported by great strengths in the basic sciences, the arts, the humanities, and also by an orientation that addresses the pervasive international aspects of all these areas of study, many of which until recently could be thought of as purely domestic. Together these studies provide unique leverage on some special contemporary issues: assessing the impact of technology, improving the skill with which social and industrial organizations are managed, enhancing international security and cooperation, increasing the efficiency with which scarce resources are used, bringing artistic and human understanding into a more productive relationship with science and engineering, ensuring freedom and privacy and opportunities for all — enhancing in all ways the roles and lives of all people in technologically based societies.

Taken as a whole, these strengths especially qualify MIT to address the sociotechnological dilemmas now confronting the nation and the world. From its students and faculty will come new resources, new technologies and techniques, new industries, new intellectual groupings, new living environments, new systems, new freedoms, and the fulfillment of important new expectations.

To scale its contributions to the needs and opportunities appropriate for today and tomorrow, the Institute has undertaken the MIT Leadership Campaign to assure an excellent faculty and outstanding students, to support significant experiments in crucial fields, and to provide a limited number of critically needed core facilities. The campaign, carefully planned to underwrite and extend the quality and strength of vital programs, is based on the belief that present world problems — serious, complex, and even discouraging as they sometimes seem — are in reality unprecedented opportunities for innovative individuals and institutions.

We at MIT are convinced that it is possible to expand greatly our understanding of the world and increase the wisdom and effectiveness with which we manage our affairs and use our many talents and resources. There are before us enormous opportunities to make each person's life a more rewarding experience, spiritually and culturally as well as materially, here and now, in our own time.

The fundamental purpose of that campaign to raise


MASSACHVSETTS

$225 million in private gifts over a five-year period was to provide the resources to meet those challenges — to undergird the financial stability of MIT in order to maintain the Institute's high quality of teaching and research, to provide the flexibility needed to explore and pioneer new fields of importance to the nation and to the world, and, especially to enhance even further the education of the superbly qualified young men and women who will play an important role in the leadership of the future. Hard work and dedication of the entire MIT family — faculty, staff, Corporation, and administration — made the Leadership Campaign a success. On its fifth anniversary, on April 22 of this year, the total stood at $250,232,000, roughly 10 percent in excess of the original target. Since that date, substantial additional gifts have been recorded, and it appears that the momentum of the Campaign will result in a sustained higher level of annual giving. This effect can be seen most dramatically in this year's record Alumni Fund contributions to the Institute of $6.3 million, a 22.5 percent gain over 1979.

The final total of $250.2 million realized by the Leadership Campaign included $68.1 million in new endowment, $60.7 million for facilities, and $121.4 million for new programs and for current use. The gifts included $93.1 million contributed by individuals and $80.8 million from foundations. We especially appreciate the strong support MIT received from industry in the Campaign. This special relationship with business and industry has always been a hallmark of MIT, and the $74.7 million given by both American and foreign firms during the last five years underscores the continuing vitality of this interaction. Of the total industrial support, $15.3 million was received for memberships in our unique Industrial Liaison and Associates programs, which have increasingly provided a powerful and productive link with industry.

Central to the Campaign was the goal of substantially increased endowment — especially for professorships and student aid. Through the Campaign, specific gifts were made to endow 45 new professorships, including both senior professorships and the career development professorships so important to the support of younger faculty members. The new endowments, including those received after the close of the Campaign, already completed, bring to over 100 the number of endowed chairs and career development chairs now available to the Institute. In spite of this impressive progress, the number of available endowed professorships is still small relative to the quality of the MIT faculty or to the numbers of chairs at comparable institutions. We must continue to seek additional support for this purpose.

Our critical need for endowed funds for student aid also received a substantial boost during the course of the Campaign, and our initial goal has been exceeded. All told, endowment to provide future student aid has reached $13.6 million, compared to an original objective of $10 million. At the same time, the need in this area has grown, and we must continue to seek new endowment.

New facilities were not the dominant thrust of the Campaign, but generous support was forthcoming, nonetheless, for several key structures for which the Institute had essential and even critical need. Presently, construction is under way on major campus facilities that include the new Whitaker College of Health Sciences, Technology, and Management; the health services facility; the Athletics and Special Events Center; a new undergraduate residence on Memorial Drive; and on several vital renovation projects, including spaces to be used by the Sloan School and the Program in Science, Technology, and Society.

Throughout the Campaign, support for research and teaching programs was emphasized, and nearly half the funds raised have been provided for a multitude of current purposes in our five Schools; and in our many interdisciplinary laboratories, centers, and programs, including the Program in Science, Technology, and Society, and the Whitaker College. Of special importance is the $17.3 million we have received in unrestricted gifts — the kind of support that continues to be of inestimable value to the Institute in our ongoing efforts to maintain flexibility in funding new projects, while operating on a carefully controlled budget.

Needless to say, the Campaign did not end MIT's need for new resources. The specifics of the $225 million Campaign goal represented our perception five years ago of the highest priorities among a set of needs that totaled more than $400 million. The target represented our best judgment of an achievable effort. Since the start of 1975, inflation has added substantially to the costs of building projects and operations, and new needs in facilities and opportunities in academic programs have emerged. Consequently, even though we are pleased and gratified by the results of the Leadership Campaign, we gird ourselves for a continuing effort to seek additional resources for the Institute.

Because of the success of the Leadership Campaign, the Institute has had more of the resources, in the face of serious economic storms, needed to play its traditional role of leadership in helping to meet the nation's needs. We are pleased with the continued development of the many programs, old and new, basic and applied, undergraduate and graduate, and of the many critical new facilities that the

Leadership Campaign has made possible. We draw particular satisfaction from the broadening of MIT's intellectual base in the life and health sciences, the social sciences, the arts, and the humanities.

VERY LARGE SCALE INTEGRATED CIRCUITS, THE BRAIN SCIENCES, AND ARTS AND MEDIA TECHNOLOGIES

Many of these new programs have a unique MIT personality, typically interdisciplinary, usually drawing much of their strength from links with on-going activities in engineering and science. Sometimes the influence of the older activities is direct, as in the impact of the physical sciences on the life sciences and medicine, or the influence of information-handling technology on the cognitive sciences and linguistics, and on the emerging program in media technology. Sometimes it is indirect, and is more the influence of the MIT ambience than specific interactions, as in the case of economics, psychology, and the humanities.

The past year saw attention focused on three burgeoning new activities. During the year the Department of Electrical Engineering and Computer Science committed itself to a new program in the design of large-scale integrated circuits, which hold the promise of revolutionizing much of our manufacturing activities as well as our functioning as a society in an information-rich era. This program represents a major effort by the Institute to educate more engineers expert in this important area and, at the same time, to contribute to the development of the field. It is a particularly interesting endeavor that involves the confluence of the physical sciences and the information sciences on an engineering discipline.

Integrated circuits now involve so many circuit elements and so high a degree of complexity that traditional engineering design techniques are becoming too time-consuming and costly. It is hoped that a major advance in technique can be achieved by adapting artificial intelligence techniques to the circuit design problem. But more than design advances are involved here. Most of the circuits themselves involve the need to better understand complex information processing systems: they are expected to be increasingly "intelligent" devices able to perform progressively complex tasks of computation, logic, and simulation.

The year saw, too, modest progress in the conceptualization of how MIT's manifold activities that relate to brain, behavior, cognition, neurochemistry, neuroendocrinology, perception, sensory communication and sensory defects, learning, and learning disorders can interact most effectively. The difficulty of structuring these activities should come as no surprise to anyone who has tried to reflect on or work in these areas. They span a multitude of levels of organization, from the molecular to the whole organism — organisms whose repertory of behaviors range from the most primitive to the most humanly complex.

We want, of course, to understand how the brain develops as the organism learns and matures. We want to be able to remedy conditions, whether genetically given or environmentally induced, from birth defects to memory disorders in old age. We want to be able to take advantage of both new neuropharmacological findings and the most sophisticated computers to ensure excellent physical and mental health.

But in spite of the significant progress to which an increasing number of neuroscientists contribute in many countries, we do not understand enough to construct even an approximate theory of brain function; we do not yet know which experiments will lead to the hoped-for breakthroughs. In such circumstances, there are at the Institute several academic units and disciplines that contribute — through instruction and research — to the education of a new generation of brain scientists, a generation that will be in possession of more of the requisite techniques, models, and tools. In the midst of such complexity, there arise at any given time promising clusters of problems which attract clusters of colleagues from several disciplines who see an advantage in banding together in a center that will provide an intellectually more diverse environment than any single department is able to provide. Thus arose, for instance, the Center for Cognitive Science on which we reported last year. It appears that the time is now ripe for a grouping of the more biomedically oriented approaches into a Center for the Brain Sciences (or Neurosciences). Obviously the MIT Psychology Department, in the tradition of Hans-Lukas Teuber with its great strength in neuroanatomy, neurophysiology, and visual perception, is a keystone in such a grouping. But there are nearly a dozen MIT departments and laboratories in which research on the nervous system is being conducted. This obviously renders a single spatial focus impossible; however, the facilities of the Fleischmann Center for the Brain Sciences in the Whitaker College building should enable us to broaden and deepen our efforts in this area by bringing together several groups that will truly complement each other, and that will allow us to offer more powerful educational programs to MIT students.

A third major area of activity is the effort, stimulated by the MIT Council for the Arts, to provide more adequate facilities for the Institute's developing program in the arts and media technologies. This initiative has converged during the past year into a plan to bring together in a single more adequate facility the flourishing MIT exhibitions program, the creative activities in film, video and still photography, the campus-wide video production facilities, the computer music developments, the Visible Language Workshop, and the growing research and teaching activities in the area we have chosen to call media technology. By media technology we mean the emerging uses of video display and storage techniques, coupled with computer data processing and retrieval means, to facilitate human interaction with large amounts of stored information. We believe this new area holds the promise of enhancing many types of creative work (as computer-aided design has already done) by extending the

reach and capabilities of the human intellect. We see, too, new publishing endeavors, involving the interaction between wideband information storage and computers. And, finally, we see in this work exciting possibilities of new learning tools and opportunities. Hardly anywhere can one find a wider spectrum of creative arts and research in related technologies than here at MIT.

In the planning process for the new arts and media technology facility, we have seen the benefits of working together across the traditional boundaries that separate these many fields. We expect that by making it possible for students and faculty in these various fields to interact more easily we will create a truly unique environment for the interaction between the arts, the humanities, and technology.

These developments are part of two major technological thrusts that offer great new societal and industrial opportunities today: the development and use of sophisticated information processing technology, and the development of the biomedical and agricultural technologies stemming from the deepening understanding of biological processes. Interestingly, these can be viewed as rather different aspects of a converging evolution of information systems, one flowing from human efforts to create systems for the processing and transmission of increasingly complex information, and the other from the study of information in living systems, including the life processes themselves.


Charlie Freeman

THE INFORMATION SCIENCES

As we look across the decades of our involvement with MIT, we can discern several basic, not unrelated, developments that have transformed the Institute. The first, of course, is the growing interaction among disciplines — between science and engineering, and among the engineering fields — producing new disciplines such as biophysics, biochemistry, astrophysics, computer science, biomedical engineering, and other engineering and engineering science fields. Another basic development has involved the life sciences, as the tools of physics, chemistry, and information technology are brought to bear on the mysteries and problems in the biological realm. And, as noted above, we have seen the emergence of a wholly new area of intellectual study: the information sciences are now taking their place alongside the physical and life sciences.

These developments were mentioned briefly in last year's report, but their full sweep and implications were not emphasized. It is frequently said today that the world is engaged in a second industrial revolution, based on information technologies. In the first industrial revolution, machines came to be used to augment human and animal power in performing routine and difficult manual tasks. Similarly, it is often noted that information processing and computing systems are increasingly replacing humans in the performance of routine mental tasks. We can list many examples of this movement, ranging from the development of hand calculators, computers, and guidance systems to computer-controlled machine tools. But studies and applications of information processes extend far beyond such straightforward substitutions of machines for people.

Information systems will be able to do many things that humans cannot do. They will help reduce energy consumption by continuously optimizing energy-consuming processes. They will make it possible to better manage our complex society through the collection and processing of data on a scale heretofore impossible, through the study of the behavior of complex systems by means of computer simulation, and by the speeding up of responses and interactions.

Discoveries regarding the information flow in living systems could well have an even greater impact than machine systems, ranging from the biotechnologies beginning to be in use to major contributions to health and education. Information-related research in what we might perhaps best call the human sciences (such as human biology, the neurosciences, the cognitive sciences, and linguistics) proceeds as yet fairly independently of machine-related work in computer and information sciences; nevertheless they enrich each other by shared understandings and research tools. The concept of coding, for example, drawn from the electrical communication field, is central to explaining certain fundamental biological processes. On the other hand, understanding the process whereby humans produce speech has made possible the computer-simulation of speech and will no doubt one day lead to practical speech recognition machines. This synergism, flowing from the simultaneous exploration of intricate living systems and increasingly complex man-made systems, has a most exciting frontier where the two paths intersect. At this junction are found, for example, the efforts to make "intelligent" prosthetic devices such as nerve-actuated artificial arms and legs, and reading and guidance devices for the blind. Here, too, are the rapidly

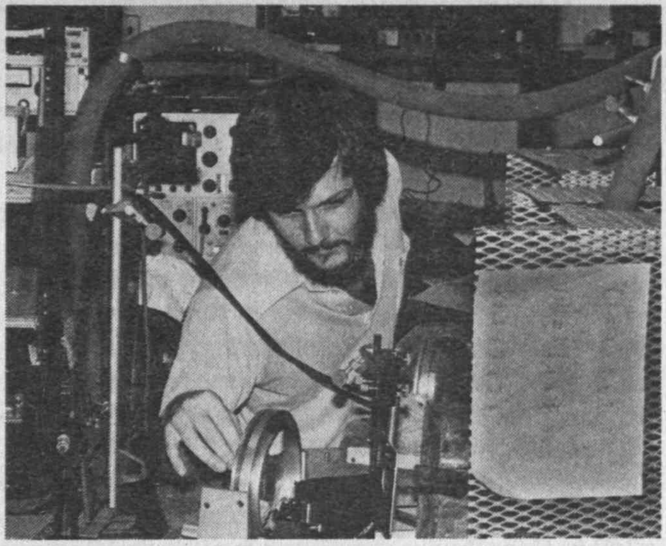
developing efforts to exploit the power of computer and video technologies to enhance the interactions between humans and machines and thus to provide powerful new learning tools.

At MIT, the interest in information as a subject worthy of study had its origins in the computer and servomechanism work of Vannevar Bush and his colleagues, in the pioneering studies of Norbert Wiener and Arturó Rosenbluth concerning feedback in living systems, and in the early work of Claude Shannon on switching logic which later led to his by now classical theories on communication and information systems.

Many of these ideas were brought into focus by the technical developments which occurred during World War II, particularly in the field of radar, and by the concepts developed by Norbert Wiener in his enormously influential book, *Cybernetics,* which focused attention on the all-pervasive nature and fundamental importance of information to life. Wiener, along with his contemporaries von Neumann, Pitts, and McCulloch, made important advances in comparing and contrasting neurons and switches, as well as important suggestions regarding the ways in which both man-made information systems and the nervous system process signals.

Wiener's and Shannon's ideas fell on receptive and creative minds, and led in time to a broad-ranging set of research activities involving both engineers and scientists. This work was initially centered in the Research Laboratory of Electronics, and included studies of electrical signals and noise, coding systems, signal transmission in the nervous system, speech, vision and hearing, sensory prostheses, group communications, and the interaction between humans and machines. Participating in these new ventures were electrical engineers, students of brain function, psychologists, linguists, mathematicians, and people from a host of other disciplines. These early activities have long since outgrown the boundaries of RLE:

- the Departments of Psychology and of Linguistics and Philosophy have taken their place on the MIT scene;
- the computer sciences have found their own identity, and have spawned an Artificial Intelligence Laboratory very active in the area of vision;
- fundamental biology has turned increasingly to the informational aspects of life;
- work on the auditory system has given rise to the Eaton Peabody Laboratory of Auditory Physiology, a model of how new methods from communication and information technology can powerfully influence the practice of medicine;
- linguistics, experimental psychology, computer science, and artificial intelligence have come together to study cognitive processes;
- explorations of computer-aided design in the Department of Architecture have led to a sophisticated media-technology program which has far-reaching implications regarding our storage and retrieval of information;



Tom Vasicek

- the study of the role of information systems in management has become embedded in the Sloan School;
- certain facets of the cognitive sciences and the use of computers as learning tools have become *foci* of much that is done in the Division for Study and Research in Education; and
- the prospects of the personal computer as an intellectual tool are now emerging.

Information science and technology, a somewhat diffuse set of activities, clearly has taken its place along with the traditional physical and life sciences and the engineering disciplines that build upon them. It is clear, too, that while much of a fundamental nature is yet to be understood regarding this somewhat mysterious commodity — information — its ramifications will continue to grow in societal importance. It is evident also that MIT, with its many programs in which learning about information processes plays a central role, is and will continue to be a world leader.

IN SPECIAL RECOGNITION

The honors and achievements of MIT faculty have been many this year. In this part of our report we mention some highlights of the individual efforts and awards which lend such distinction to the Institute.

This past winter, seven MIT faculty members (all of whom are alumni of the Institute) were elected to the National Academy of Engineering. The new Academy members are Eugene E. Covert, Professor of Aeronautics and Astronautics; Nicholas J. Grant, Professor of Metallurgy; Karl Uno Ingard, Professor of Aeronautics and Astronautics and of Physics; Robert C. Reid, Professor of Chemical Engineering; Herbert H. Richardson, Head of the Department of Mechanical Engineering; Gerald L. Wilson, Head of the Department of Electrical Engineering and Computer Science; and Laurence R. Young, Professor of Aeronautics and Astronautics. Their election brings to 59 the number of active and emeritus MIT faculty members in the Academy.

In April, two members of the MIT faculty were elected

to the National Academy of Sciences, bringing to 78 the number of MIT officers and faculty members (active and emeriti) in the Academy. The two new members are Professor Herman Chernoff of the Department of Mathematics and Professor George W. Clark of the Department of Physics.

And in May, four MIT faculty members were elected to membership in the American Academy of Arts and Sciences. They are Rudiger Dornbusch, Professor of Economics; Jerome I. Friedman, Professor of Physics; Merton C. Flemings, Ford Professor of Engineering; and Emilio Bizzi, Eugene McDermott Professor of Brain Science and Human Behavior. Also elected to the Academy was Ralph Landau, a life member of the MIT Corporation, Chairman of the Corporation Visiting Committee for the Department of Materials Science and Engineering in 1979–80, and a member of the Visiting Committees for Chemical Engineering and Nutrition and Food Science.

Of special note this year was the selection of Institute Professor, Emeritus, Victor F. Weisskopf as a recipient of the national Medal of Science, awarded by the President to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, and engineering sciences." Professor Weisskopf was honored for his theoretical work in quantum electrodynamics and in nuclear and particle physics. Professor Weisskopf also served as President of the American Academy of Arts and Sciences this past year.

Especially noteworthy was the selection this spring of former President and Chairman of the Corporation, Dr. James R. Killian, Jr., as the first recipient of the Vannevar Bush Award by the National Science Board, the policy-making body of the National Science Foundation. Besides serving the nation, its government, and its institutions in many ways, Dr. Killian was the nation's first full-time presidential science advisor when he served in that capacity to President Dwight D. Eisenhower. The Award was established by the National Science Board to be given in recognition of outstanding contributions to science and technology through public service. It was named in honor of the late Vannevar Bush, former professor, vice president, and dean of engineering at MIT. In 1945, Dr. Bush recommended to President Harry S. Truman that the Congress establish a foundation to support and encourage basic research and education in the sciences and to develop a national science policy. Five years later the Congress passed a bill creating the National Science Foundation to fill these roles.

In August 1979, Dr. John M. Deutch, Arthur C. Cope Professor of Chemistry, who had been on leave in various capacities in the Department of Energy, was sworn in as Undersecretary of the US Department of Energy, and served in that post until his return to the Institute in the spring of 1980. As Undersecretary, Dr. Deutch guided nuclear policy research, development of alternative energy sources, and defense and environmental programs. In March of this year he received a Tribute of Appreciation from the Department of State.

Within the Institute, special honor was given to Dr. Alexander Rich, Sedgwick Professor of Biology, who was selected as the 1980–81 recipient of the James R. Killian, Jr., Faculty Achievement Award. The Award is given each year to a member of the faculty in recognition of exceptional professional accomplishment and service to the Institute. Citing his recent discovery of a new double helical form of left-handed DNA, the Award states in part: ". . . his research at MIT reveals a record of scientific work remarkable for its vision and quality . . . As a scientist with a voice in world affairs he represents the scholar who is concerned with the uses of knowledge as well as its discovery. . ."

Several changes in senior posts in the academic administration occurred during this past year. They include several changes in the Provost's area of responsibility. As noted above, Professor Francis E. Low was chosen to succeed Professor Walter A. Rosenblith as Provost. At the end of the academic year, Associate Provost Hartley Rogers, Jr., stepped down from that position after serving in that post for six years. Among his other duties were special responsibilities for educational video programs, the Office of Minority Education, and long-range planning for continuing education. In May, Mr. Joel Orlen, executive officer in the Office of the Provost, left the Institute to accept a vice presidency with the Minneapolis/St. Paul Museum of Science. In June, Professors Frank E. Perkins and Kenneth A. Smith were named Associate Provosts in the incoming administration. Other changes in the academic administration included the following appointments: Dr. John V. Evans, Director of the Haystack Observatory; Dr. James R. Melcher, Director of the High Voltage Research Laboratory; Dr. Merton C. Flemings, Director of the newly organized Materials Processing Center in the School of Engineering; Professors

Ernest G. Cravalho and Christopher T. Walsh, Associate Directors of the recently established Whitaker College of Health Sciences, Technology, and Management. In addition, Drs. Richard L. Cartwright and Pauline R. Maier served as Acting Head and Acting Associate Head, respectively, of the Department of Humanities, until the appointment (effective July 1, 1980) of Professor Peter H. Smith as head of the Department and Associate Dean for the Humanities Programs; Dr. Abraham J. Siegel agreed to serve as Acting Dean of the Sloan School of Management, succeeding Dr. William F. Pounds, who stepped down as Dean after almost 14 years in that post in order to pursue other areas of interest; and Professor Royce N. Flippin, Jr., was appointed Director of Athletics (effective July 18, 1980), succeeding Professor Ross H. Smith, who had held that position for 19 years, prior to his retirement at the end of the 1979–80 academic year.

Several changes in senior administrative positions should also be noted. In April, Dr. Shirley M. McBay came to the Institute as Dean for Student Affairs — following a lengthy review and reorganization of the student affairs area conducted by Vice President Constantine B. Simonides. A major outcome of that review was a renewed emphasis on support by the Dean's Office to the academic program. Prior to coming to MIT, Dr. McBay was Program Director in the Science Education Directorate of the National Science Foundation. Other changes included the appointment of the Director of the Physical Plant, William R. Dickson, as Vice President for Operations, succeeding Philip A. Stoddard who retired at the end of the year after serving 19 years as Vice President. In March, John M. Wynne, Vice President for Administration and Personnel, left the Institute after a career of 22 years at MIT, which included his serving as Director of the Executive Development Programs and as Associate Dean of the Sloan School, prior to his appointment as Vice President in 1967. His responsibilities were assumed by Constantine B. Simonides, Vice President in the Office of the President, who now has senior responsibility in the broad area of human resources, including the various student-related services, personnel, information services, and the MIT Press.

Within the Corporation, Vincent A. Fulmer, Secretary of the Institute, was elected Secretary of the Corporation at the annual meeting in October 1979, succeeding John J. Wilson, who in his capacity as Secretary since 1959, had signed nearly 45,000 MIT degrees. Mr. Wilson, who was elected Honorary Secretary, continues as the senior active Life Member of the Corporation.

We were saddened this year by the deaths of a number of colleagues whose presence we miss, yet whose contributions to the stature and character of MIT are long-lived and gratefully remembered.

Joseph Dee Everingham, Director of Drama and Professor of Literature, died in March 1980 at the age of 63. Professor Everingham, who founded and developed MIT's undergraduate drama program, served as producer and director of many MIT Dramashop productions.

Murray F. Gardner, Professor of Electrical Engineering, Emeritus, died in August 1979. Internationally known for his work in the field of operational circuit analysis, Professor Gardner was a member of the MIT faculty for 35 years.

George Russell Harrison, Dean Emeritus of the School of Science, died in July 1979, following a long illness. An experimental physicist and spectroscopist of world renown, Professor Harrison served for 22 years as Dean of our School of Science, and set standards of excellence and achievement that have made science teaching and research at MIT preeminent throughout the world.

Harold L. Hazen, Dean Emeritus of the Graduate School, died in February 1980, at the age of 78. Dr. Hazen's seminal contributions to the field of automatic control and his dedication to research as the basis of advanced education were important building blocks in the development of MIT. During Dr. Hazen's 15-year tenure as Dean of the Graduate School, the School doubled in size and its reputation for excellence grew.

Daniel Lerner, Ford Professor of Sociology and International Communications in the Department of Political Science, died in May 1980, at the age of 62. A political sociologist, Professor Lerner was noted for his work on the role of communications in the development of third world nations.

Gilbert W. Low, Assistant Professor of Management, died in July 1979 in an automobile accident, at the age of 40. In addition to his teaching responsibilities, Professor Low was associated with the Sloan School's Systems Dynamics Group.

Theodore A. Mangelsdorf, a former member of the Corporation and a benefactor of MIT, died in August 1979, after a brief illness. An MIT alumnus, Mr. Mangelsdorf was associated with Texaco, Inc., throughout his career. Mr. Mangelsdorf served as President of the Alumni Association in 1966–67, and was the principal architect in the establishment of the New York Alumni Center.

Benjamin R. Martin, lacrosse and hockey coach for 29 years, died suddenly in January 1980, at the age of 68. One of New England's top lacrosse officials, Mr. Martin coached MIT teams from 1945 until his retirement in 1974.

Robert J. Radocchia, retired Manager of the Walker Memorial Dining Service, died suddenly in June 1980, at the age of 65. Mr. Radocchia, who had been associated with MIT for more than 40 years, was chairman of the board of the MIT Quarter Century Club. He had been singularly responsible for the development and fostering of many activities promoting a sense of community at the Institute.

Carl Richard Soderberg, Institute Professor, Emeritus, former Head of the Department of Mechanical Engineering, and former Dean of the School of Engineering, died in October 1979, at the age of 84. Dr. Soderberg was an internationally recognized engineer whose work advanced the art of steam turbine design and hastened the development of

aircraft jet engines. Considered one of MIT's most illustrious teachers, Dr. Soderberg is credited by many of his colleagues with having built the world's leading mechanical engineering department at MIT — a department that has for years been ranked first in the nation.

Robert B. Woodward, a former member of our Corporation and professor of Chemistry at Harvard, died suddenly in July 1979. An MIT alumnus, Professor Woodward received the Nobel Prize for Chemistry in 1965. Professor Woodward served on the Corporation from 1966 to 1971.

STATISTICS FOR THE YEAR

The following paragraphs report briefly on the various aspects of the Institute's activities and operation during 1979–80.

REGISTRATION

In 1979–80 student enrollment was 9,053, compared with 8,881 in 1978–79. This total was comprised of 4,517 undergraduates (compared with 4,594 the previous year) and 4,536 graduate students (compared with 4,287 the previous year). Graduate students who entered MIT last year held degrees from 371 colleges and universities, 232 American and 139 foreign. The international student population was 1,727, representing nine percent of the undergraduate and 29 percent of the graduate student population. These students were citizens of 96 countries.

Degrees awarded by the Institute in 1979–80 included 1,117 bachelor's degrees, 985 master's degrees, 77 engineer's degrees, 387 doctoral degrees — a total of 2,566.

The number of women at MIT, both graduate and undergraduate, has continued to increase. In 1979–80, there were 1,565 women students (806 undergraduate and 759 graduate) at the Institute, compared with 1,466 (790 undergraduate and 676 graduate) in 1978–79. In September 1979, 207 first-year women entered MIT, representing 20 percent of the entering class.

Minority* students at MIT have increased in numbers as well. In 1979–80, there were 771 minority students (579 undergraduate and 192 graduate) at the Institute, compared with 685 (494 undergraduate and 191 graduate) in 1978–79. The first-year class entering in September 1979 included 172 minority students, representing 16 percent of the class.

**Minority students include Blacks (non-Hispanics), Native Americans (including Alaskan Natives), Hispanics, and Asian or Pacific Islanders.*

STUDENT FINANCIAL AID

During the academic year 1979–80, the student financial program was again characterized by increases in overall need for financial aid, and in the aggregate amount of grants made available. There was a slight increase in the amount of MIT loans awarded, and a large increase in loans obtained from commercial sources.


Jim Snyder

A total of 2,125 undergraduates who demonstrated the need for assistance (47 percent of the enrollment) received $7,053,446 in scholarship aid and $2,507,679 in loans. The total, $9,561,125, represents a six percent increase in aid compared with last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $2,527,139; by outside gifts to MIT for scholarships in the amount of $1,504,827; and by direct grants from outside agencies to needy students totaling $2,384,110, an increase of 44 percent from last year. Scholarship assistance from MIT's own operating funds was provided to the extent of $511,477. The special program of scholarship aid to minority group students represented an additional $125,893 from specially designated funds. An additional 371 students received grants from outside agencies. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of about $1,119,000 (four percent) and which raised the principal of the endowment to $28,088,000.

Loans totaling $2,507,679 were made to needy undergraduates — a 13 percent increase over last year. Of this amount, $437,711 came from the Technology Loan Fund and $2,069,968 from the National Direct Student Loan Program. Not included in the foregoing summary is an additional $3,534,074 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources. This represents an 83 percent increase in the use of these programs over last year.

Graduate students obtained $504,636 from the Technology Loan Fund, $197,270 of which was loaned under the Guaranteed Loan Program and qualified for Federal interest subsidies and guarantees. In addition, $471,269 was loaned from the National Direct Student Loan Program. The total, $975,905, represents a two percent reduction compared with last year's level. The total loaned by MIT to both graduate

and undergraduate students was $3,483,584, an increase of seven percent from last year's total — but all of the increase was borne by the Federal National Direct Student Loan Program; loans from the Technology Loan Fund actually decreased.

CAREER PLANNING AND PLACEMENT

The past year was one of continuing growth in the number of students using the Office. An estimated 1,200 students came to talk with the staff about their career plans or to meet with company and graduate school representatives. An invitation to United States students in science and engineering to submit resumés for a resumé book which the Office distributes to interested companies, elicited 747 resumés. Student interviews with visiting recruiters totaled 8,718, an all-time record. Four hundred and four companies and government agencies made one or more visits, some coming three or four times during the year.

Employer demand was strong in almost all areas of engineering and the physical sciences. It was also a good year for students in other departments who had a background in computers or economics. Management consulting firms expressed an interest in hiring analytically oriented students as research associates to work with their consulting staff for two years or so before going on to graduate school for a professional degree. Some leading banks and investment firms, and some Wall Street law firms, presented similar opportunities.

Salary offers in science and engineering rose nine to 12 percent at the bachelor's level, not quite keeping pace with inflation. Salaries at the graduate level, which in recent years have risen less fast than bachelor's salaries, this year rose equally fast or faster. Offers to master's degree candidates in electrical engineering went up 15 percent and offers to masters in materials science jumped 16 percent. Offers to Ph.D. candidates rose nine percent in electrical engineering and 11 percent in chemistry. Industrial salaries were highest for Ph.D.s in electrical engineering, hitting a median of $31,380; next was chemical engineering, at $29,280; followed by physics and materials science at $28,800.

FINANCES

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, increased from the level of 1978–79. Education and general expenses — excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory — amounted to $163,056,000 during 1979–80, compared to $144,069,000 in 1978–79. Reflected in the finances of the Institute was the use in operations of unrestricted funds of $5,792,000, compared with $5,565,000 in the preceding year.

The direct expenses of campus departmental and interdepartmental sponsored research increased from $107,521,000 to $124,296,000; the direct expenses of the Lincoln Laboratory's sponsored research increased to $127,347,000 from $102,279,000 because of an overall increase in government research support.

The construction program of the Institute continued to make progress in 1979–80 with the book value of educational plant facilities increasing from $208,195,000 to $230,488,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of $396,662,000 and a market value of $507,471,000. This compares to book and market values of $387,209,000 and $467,094,000 last year.

GIFTS

Gifts, grants, and bequests to MIT from private donors remained practically unchanged at $33,841,000 in 1979–80, compared with $33,944,000 in 1978–79. The 1979–80 figure includes unrestricted direct gifts to the Alumni Fund of $2,700,000, which constituted part of the total of $6,318,000 reported by the Alumni Fund in 1979–80.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

Campus construction activity increased substantially during the year with work being initiated on three major projects: a complete renovation of the 100,000 gross square foot (gsf) former Webster Building, the new 250 gsf Health Sciences, Technology, and Management/Health Services complex, and a new 125,000 gsf undergraduate house located at 500 Memorial Drive. In addition, work continued on the Athletic and Special Events Center, which is scheduled to

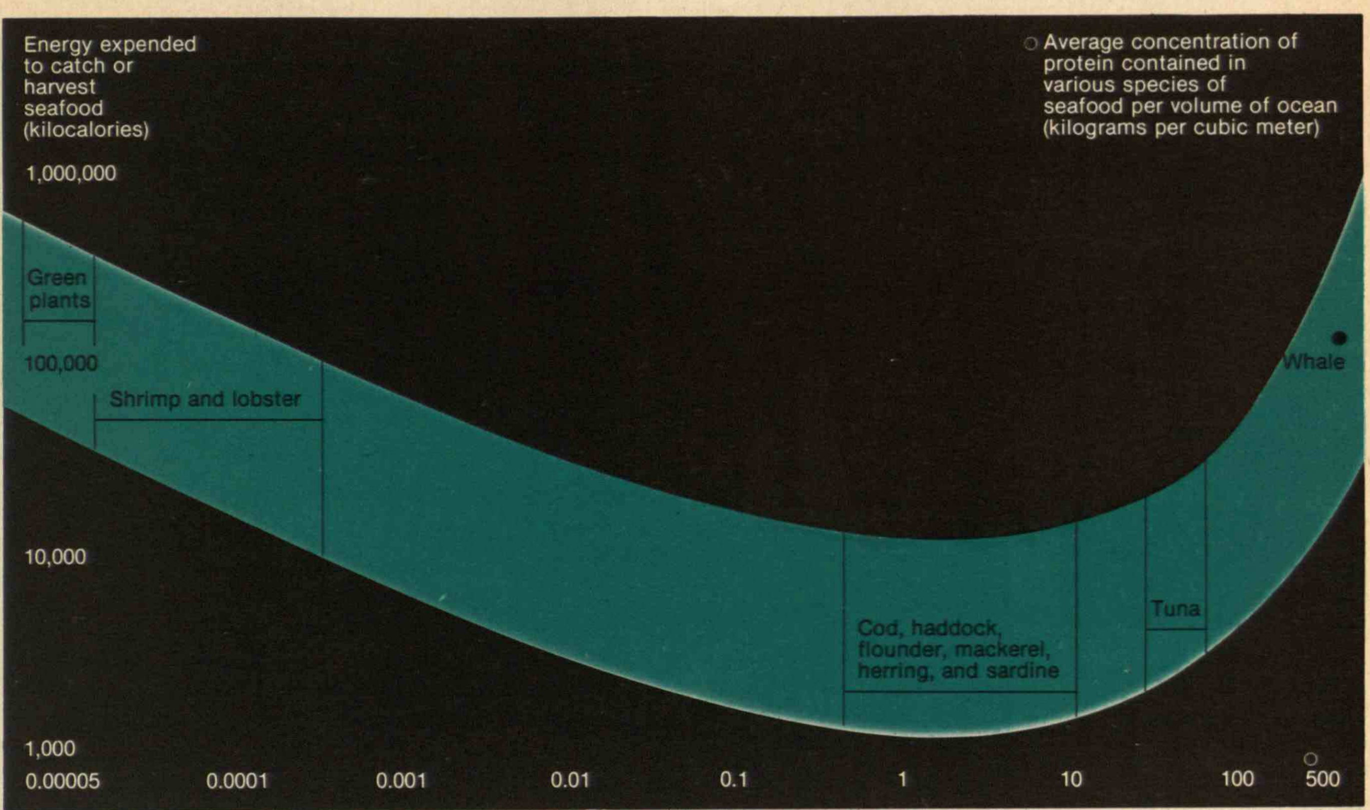
open in the fall of 1980.

In September of 1979, Kresge Auditorium was closed as a precautionary measure, five months ahead of the date previously established for a shutdown for installation of a new roofing assembly when severe deterioration of the concrete edge beams was uncovered in the vicinity of the three supporting buttresses. Alternative arrangements were made for previously scheduled events, and repair work commenced immediately. Repairs to the concrete structure were completed in the spring and Kresge was scheduled to reopen in September upon completion of the originally planned roofing operation.

The report of the Committee on Campus Dining was presented to the Chancellor in the fall of 1979. The announcement of the recommendations and programs, made in the spring of 1980, recognized that the Institute has a basic responsibility to provide food services on campus at a reasonable cost to students and that dining must enhance and complement the quality of the residence program. All concerned will strive to meet the challenge set forth by these goals in the upcoming year.

Jerome B. Wiesner, President
(1971–1980)

Paul E. Gray, Chancellor
(1971–1980) October 1980



Graph relating the expenditure of energy used to capture various kinds of marine seafood and the average value of protein in the seafood per cubic meter of ocean. For comparison, the burning of 1 kilogram of fuel oil produces about 10,000 kilogram-calories of usable energy.

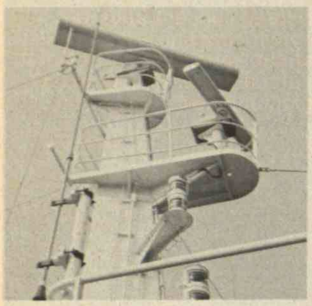
much precious fuel to harvest them. Today's market justifies this investment because tuna and swordfish are highly prized, but as fuel costs rise, the profitability of energy-intensive fisheries will become marginal, although distant-water fishing fleets will not disappear completely.

Moving to Passive Traps

By the end of this century, the majority of fishing vessels more than 30 years old will have been scrapped, and those in service will have been upgraded and modernized to continue competitive operation. If possible, engines will be converted to run on heavy grades of fuel oil since lighter grades may not be available or will be expensive. Ship operators will use satellite data routinely to navigate and determine weather and sea conditions and fish concentrations. Some vessels will carry their own advanced electronic navigational equipment and sophisticated hydroacoustical fish-detection aids such as image intensifiers and various specialized sensors (*see illustrations on pages 46 and 48*). In addition, the best-equipped ships will have on-board computers that continuously fine-tune raw data from various sensors based on acoustics (sonar) and coherent light (lasers) and that directly command the vessel's autopilot and guide the capture gear.

However, the vessels and fishing gear will change very little. Today's long-range fishing vessels already use highly refined hulls and propulsion units, and nets and net-handling techniques and equipment for processing the catch are already near optimal.

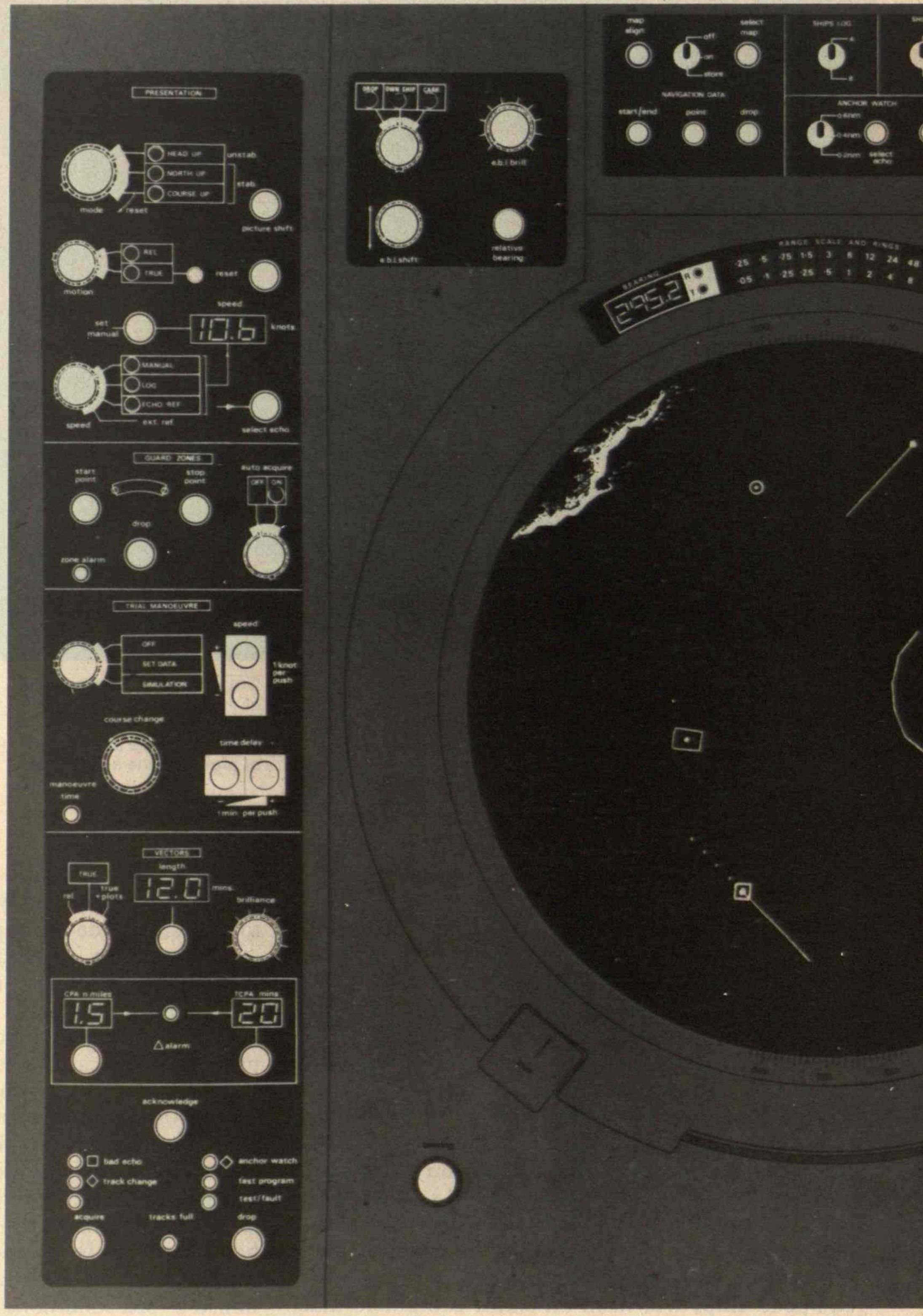
But there are only so many fish in the sea, and by the 1990s, diminishing returns on investment could precipitate a return to simpler practices. For example, today's nearly random trawl-net fishing on the continental shelves is likely to give way to the use of large passive structures that herd and concentrate fish with little expenditure of energy. The configuration of such large traps would be determined by sea conditions and the behavior and physical characteristics of the fish. The traps could be very

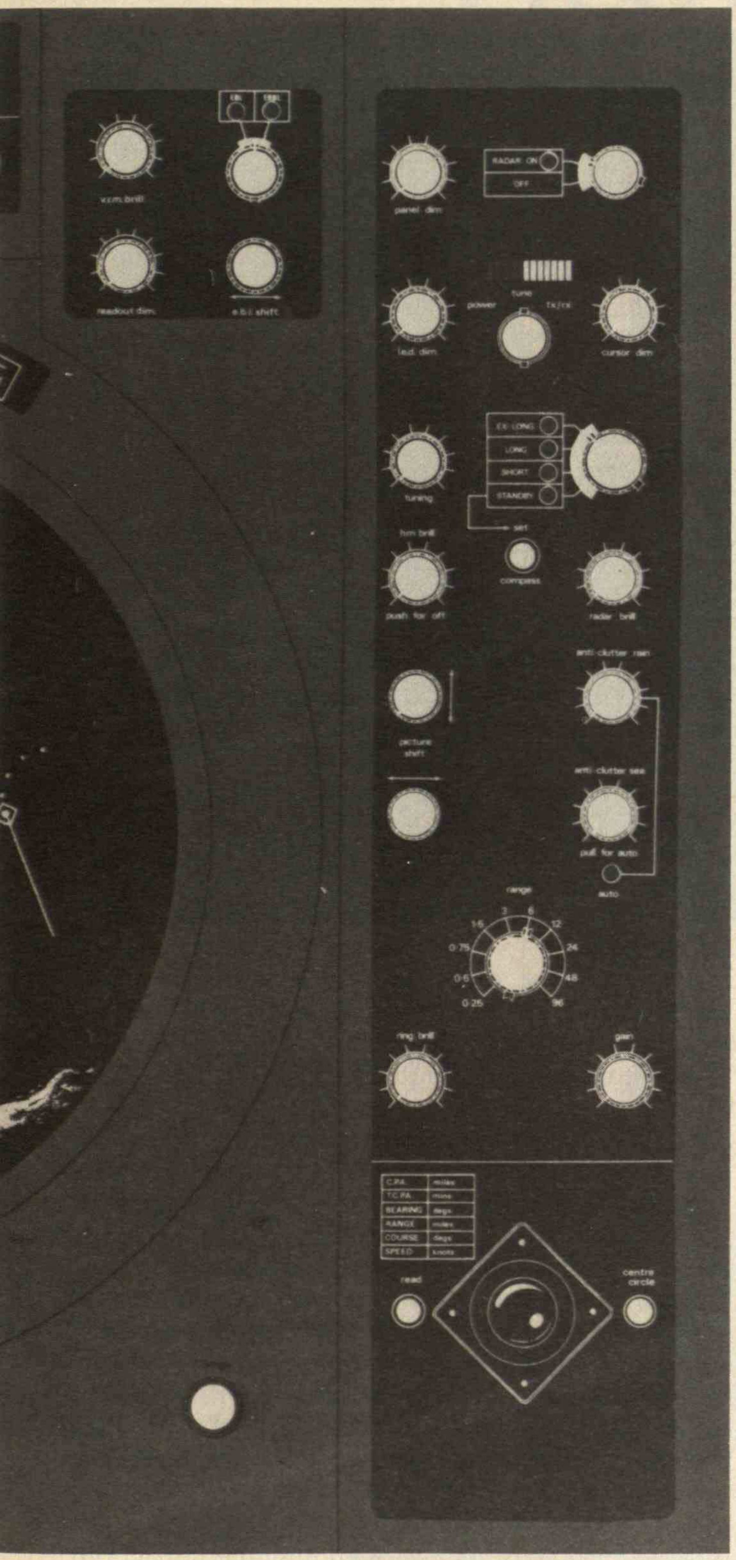


Top: Typical installation of 12-foot (10-centimeter wavelength) and 9-foot (3-centimeter wavelength) radar antennas aboard a large ship.

Above: Computerized, automatic radar-plotting aid (ARPA) with illuminated display. Six linked microprocessors digest raw radar data and display them on the screen and via warning lights and audible signals.

Right: The business end of a modern ARPA. Automatic circuits can eliminate "clutter" caused by scattering of the radar signal from the sea surface, rain, and signals generated by other radar equipment. The microprocessors continuously update all data — especially valuable during maneuvers. The equipment shown can track up to 20 targets, selected by means of the "joy stick" control located in the diamond-shaped mount at the lower right of the control panel. Impressive as these and other capabilities of such "smart" equipment may be, the operator has the option of fully manual control. (*Illustration: Racal-Decca Marine Radar Ltd., Surrey, England*)





economical because they would cover large areas and be managed far more efficiently than smaller, discrete methods. However, the initial cost of such structures would be high and their maintenance labor intensive. They could interfere with ocean transportation and other kinds of fishing gear, and they are vulnerable to sabotage and accidents.

These ocean traps or weirs, used today in shallow water, will not be cost-effective offshore until we determine with considerable accuracy how and where fish may be intercepted and harvested. Thus, further study of the behavior of many ocean species is critical for selecting the most appropriate species and sizes of fish to be captured, and for determining when fishing is least damaging to fish populations. Specialized biologists are likely to be an integral part of major fishery teams in the future.

Because it emphasizes national interests in ocean resources, the Law of the Sea will stimulate additional changes in fishing practices and strategies. For example, to ensure accurate nutritional assessment of a catch, a standard protein equivalent is likely to be adopted by most nations. Countries could use this standard to determine the value of fish captured and processed in their waters and to compare the productivity of fisheries with sources of agricultural protein.

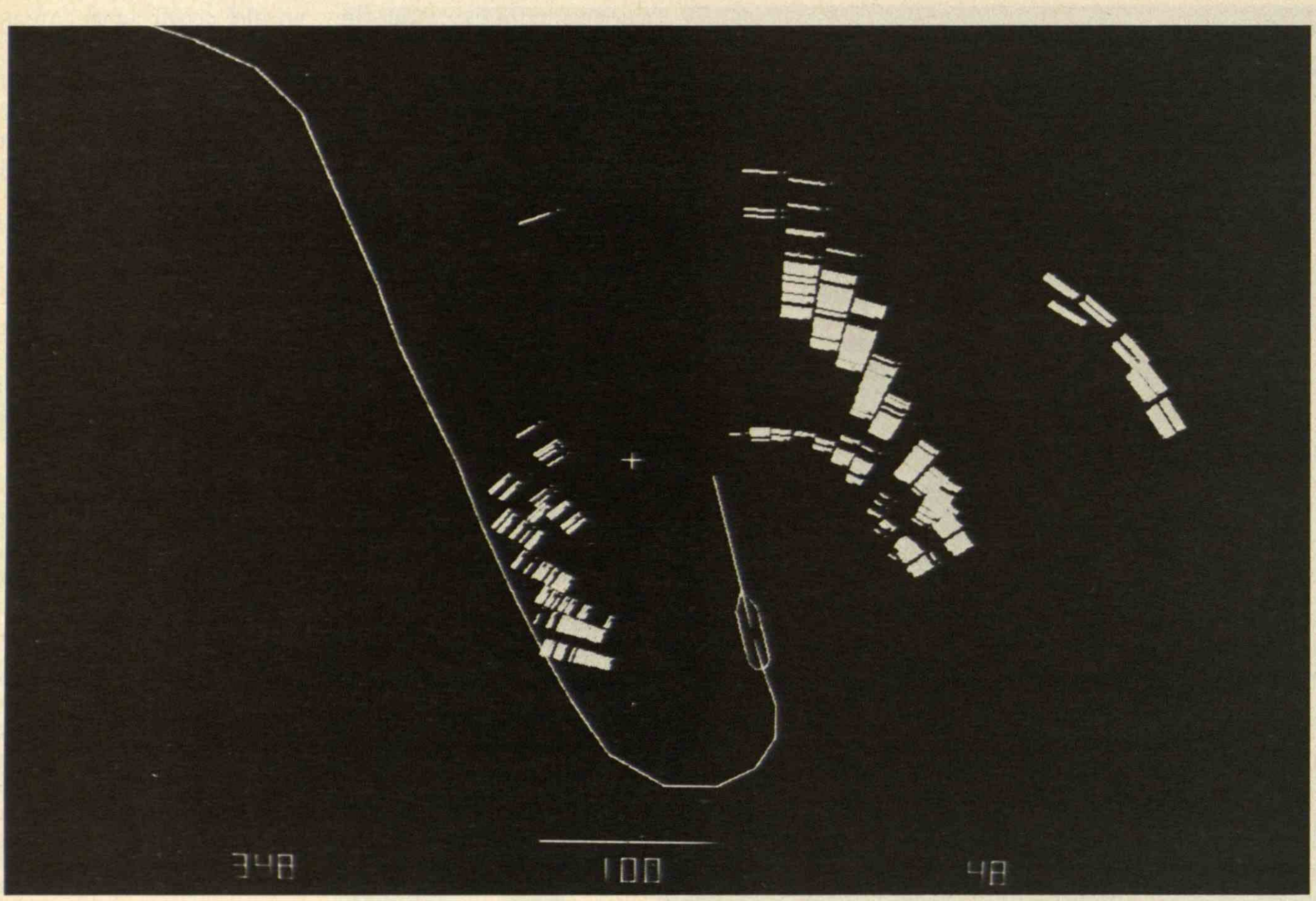
The Law of the Sea may well induce fishing vessels to work closely and cooperatively, perhaps coordinated by a central national or international organization. Directives based on biological data would specify regions to be fished, times permitted for fishing, and sizes of catches. Such coordination would minimize the waste of today's random "hunting" style of marine fishing.

Ocean Ranching and Aquaculture

The success of even the most sophisticated passive fishing techniques is limited by the dynamics of fish populations; ocean ranching and aquaculture would remove some of that uncertainty. Ocean ranching simply involves introducing desired species such as salmon in specific locations conducive to their propagation. Aquaculture, more like farming, is an attempt to propagate desirable populations and confine them to specific areas with nets, dams, and other devices.

Fish that breed in freshwater and live out their

A computer-generated plot derived from sonar data showing the track of the vessel, various sonar "contacts," and pertinent digital data. The ship is undertaking a preliminary maneuver to permit the measurement of the position and velocity of an aggregation of fish (*to the left of the vessel*). The series of short traces to the right of the vessel are echoes from the ocean surface; the series of longer traces to the far right are echoes from the sea bottom. The digital readout to the left indicates the ship's heading to be 348°, the middle readout shows that the scale of the sonar is set at 100 meters, and the readout to the right records the ship's speed as 4.8 knots. (*Photo: SIMRAD A/S, Horton, Norway*)

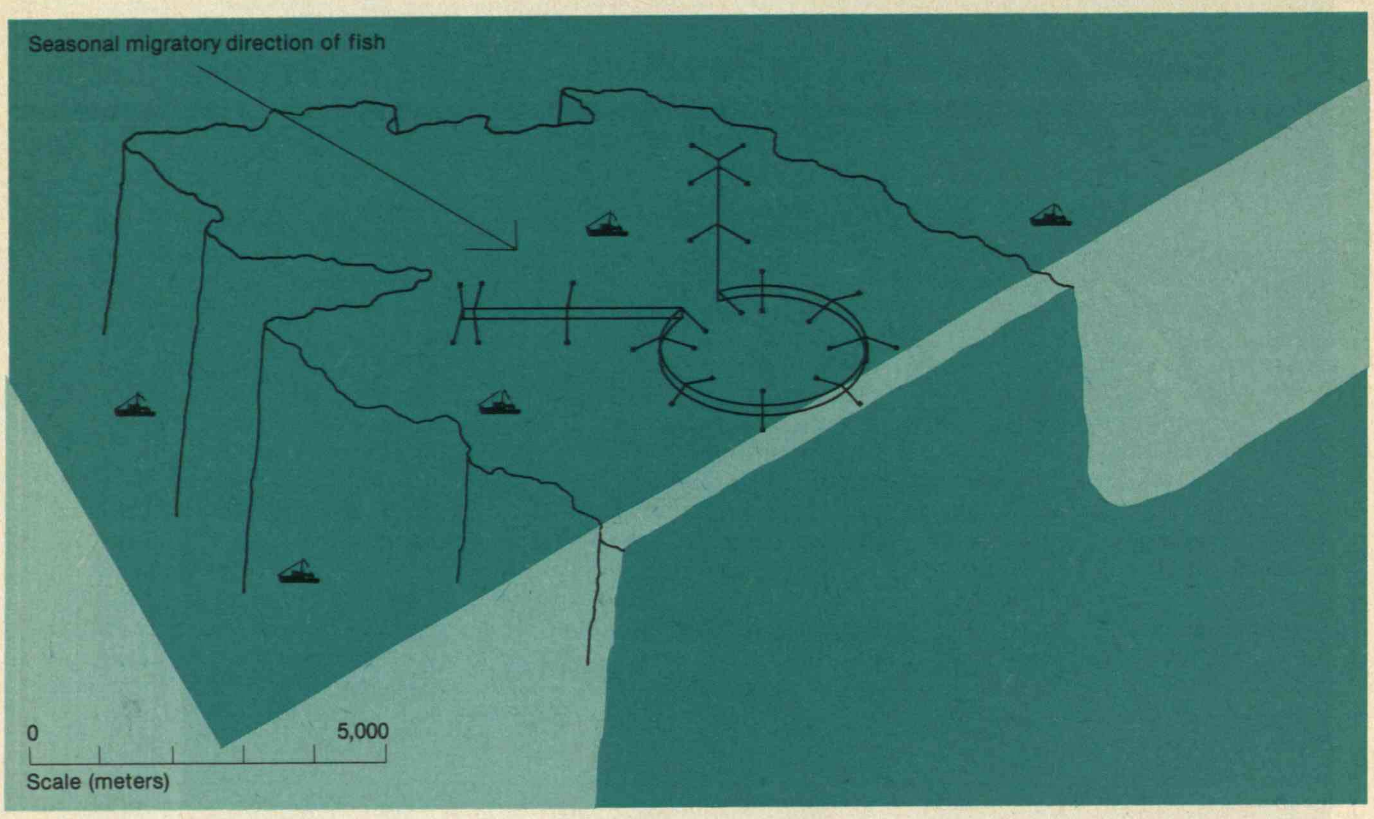


lives in the ocean are candidates for ocean-ranching ventures, as are crustaceans, mollusks, and several varieties of marine algae. The Japanese have excelled in using inshore areas for such activities. In salmon ranching, perhaps the best possibility, the salmon stock returns seasonally to the "ranch"; one could even perversely imagine them swimming up a tube to the canning factory. However, should the fish stock pass through an "unexclusive" zone, a "rancher" may well have to contend with "rustling," a practice not unknown today in international fisheries. More sophisticated approaches to the farming of bottom-dwelling organisms such as clams offer exciting opportunities: systematic seeding of areas with fast-growing, disease-resistant stocks could boost the yield of a given area by a factor of two or three. Genetic research to accelerate the natural reproduction rates of desired fish species is also possible. Indeed, the potential application of such techniques in ocean ranching seems to be limited only by the extent to which we will permit natural ecosystems to be modified to meet desired ends.

Ocean ranching and aquaculture could constitute a trump card for the twenty-first century. Given sufficient stimulus and continued support, annual fishing yields could reach 2 to 3 million tons by the year 2000. But successful ocean ranching will primarily be a means of decreasing the energy expended in fishing rather than of increasing the net harvest. Today's industrial societies expend only a slightly greater quantity of energy per unit of harvested protein from cod, haddock, and several other fish species than for the same unit of protein from rice. If the energy needed for the production of fish protein could be significantly reduced, the future of ocean ranching would be bright indeed.

The environmental issues confronting today's fisheries — how to harvest with minimal impact on other organisms in the same habitat — will have

Artist's conception of a large weir proposed for use on Dacia Bank, a seamount located about 400 kilometers west of Cape Ghir-Agadir, Morocco that rises from the ocean bottom to about 40 meters from the ocean surface. The opening of the weir is positioned to entrap migrating fish. (*Drawing: W. D. Eng, Draper Laboratories*)



very different manifestations in ocean farming. With or without the benefits of genetic engineering, ocean ranching will unquestionably alter natural ecosystems. One can envision a continuing confrontation between those interested in preserving the marine environment in its "natural" state and those desiring to increase the yield of protein from the sea. Areas with good potential for aquaculture often serve purposes such as recreation and transportation in addition to conventional fishery activities. Proponents of aquaculture — as those of other innovations — will have to compete with today's interests for their share of support.

The dawn of the twenty-first century should find coastal states exploiting their offshore zones efficiently with a variety of energy-conserving fishing devices. Research will enable fishing nations to understand how their operations affect entire ecosystems as well as individual species, and thereby help them maintain their fisheries. Nevertheless, the costs of fishing will climb, and fish — especially fresh fish — are likely to become more of a luxury protein source than today.

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Continuity and Change: Thinking in New Ways about Large and Persistent Problems

by David J. Rose

Faced with the complexities and paradoxes of real problems, people selectively ignore vital aspects and concentrate on only one or a few simple features as if those were the whole.

In 1967, the president's Science Advisory Committee wrote that the global food problem was "large, complex, difficult for most people to comprehend . . . seems deceptively straightforward and unusually susceptible to oversimplification . . . offers no promise of quick and dramatic results so helpful in maintaining enthusiasm . . . and is but one part, albeit a very important part, of the enormous problem of economic development in the poor nations."

With a few minor alterations, these remarks would apply today to many other national and global problems such as energy, environmental degradation, limits to resources, and urbanization. These problems have similar characteristics: no lack of recognition, be it ever so skewed; often no lack of information and sometimes even a surfeit; but still little amelioration. Do we, as Jacques Ellul claims in his general condemnation of what he calls *la technique*, create problems with our science and technology profoundly beyond us? But the problems are not confined to *la technique*; they are more general and have recurred throughout history.

The principle of parsimony leads us to seek other descriptions of these difficulties than those that usually appear in academic and bureaucratic discussions. Are there some underlying ideas that can help us see things better? Indeed there are, familiar though neglected, dealing with the intellectual, so-

cial, and technological mismatch between the problems themselves and our responses. This mismatch shows up in various ways: One is *selective inattention* (and its complement, selective attention), wherein faced with the complexities and paradoxes of real problems (as distinguished from classroom ones), people selectively ignore vital aspects and concentrate on only one or a few simple features, as if those were the whole. Another is *time perspectives*, in which people with different views focus on different times in the future to the exclusion of all others, and therefore suggest different responses. These responses often conflict, and adopting one may preclude others. If this sounds obvious, some of the consequences are not, as we shall see.

Our survival requires both selective attention and inattention, or we would choke in a froth of detail. We see what we focus on, and can hear a bird's song above the city noise. The mother, oblivious to danger, rescues her child from the burning house; the soldier rushes to meet the enemy, the martyr to meet his god. Love is blind and memory selective, fortunately.

Civilizations grow and collapse partly as a result of this selective attention or inattention, a combination of chance and social purpose. Consider the mathematical calculus, developed in about 1700 to solve, among other things, astronomical problems related to navigation. Three millennia earlier, the Sumerians had observed the major planets at carefully specified times, then calculated first, second, and third differences, and used them to predict future positions — but only for astrology. Their finite-difference calculus came close to Newton's work. The classic Greeks came even closer, but the social separation of artisan and scholar provided no stimulus for applied mathematics. What would our present civilization be like if conditions had been different?

A Fresh Look at Energy

Energy is ubiquitously important to both industrialized and nonindustrialized countries and affects the whole fabric of civilization. Energy involves resources, technologies, ownership and possession, end uses, environmental impacts now and later, social purpose, growth and no growth, national and international stability, future visions of society, local and global justice, and exploitive dominion vis-à-vis responsible stewardship. Nine statements about energy seem relatively immutable and therefore need to be considered from the start:

- ☐ Traditional energy resources, chiefly oil and gas, are disappearing; the remainder is becoming increasingly expensive and, to many countries, out of reach.
- ☐ The world contains about 4.4 billion people, and, barring some convulsive catastrophe, will contain more — about 2 persons per hectare of agriculturally productive land. The world will be increasingly urbanized, affecting the mix and relative attractiveness of various energy options.
- ☐ Nonindustrialized nations cannot follow the path of the industrialized ones given the present cost and consequent distribution of energy resources.
- ☐ However, large supplies of fossil fuels remain — coal, oil shale, and tar sands.
- ☐ But continued use of fossil fuel at the present rate — let alone at increasing rates — will in a few generations cause severe global environmental and climatic problems, dwarfing any that we have hitherto experienced. Chief among these is the global "greenhouse" phenomenon, the predicted consequence of carbon-dioxide buildup in the atmosphere.
- ☐ Patterns of energy consumption do not change easily in the short term, but in the longer term, many opportunities exist to use energy more efficiently and rationally, most prominently in the industrialized countries, but also elsewhere. This is often loosely called conservation.
- ☐ The energy problem, like all large societal problems, contains subissues with varying time perspectives, and the disparate responses required to suit different groups and time perspectives often conflict.
- ☐ In the long run — say a century hence — the only major available energy options will be solar and nuclear power, each in various forms.
- ☐ The international organizations and forums that attend to global aspects of the energy problem are nearly all very weak compared to national organizations that attend to national aspects.

Such a panorama of issues encourages selective inattention, wherein the investigator or advocate selectively ignores embarrassing topics or those that don't fit some preconceived idea. Each person tends to use up all the intellectual option-space (that is, the technological, economic, and political possibilities within which any reasonable decisions must fall),

Client and patron imagine they understand what needs to be done; then, by selective inattention, they ignore outside suggestions, sometimes suppressing them with sprightly and eventually geriatric vigor.

which then requires that the ignored topics be handled by some *deus ex machina*.

Here are some typical attitudes — many true in part, none true exclusively — that result from partial views:

The key to everything is conservation. There's a lot to this, but the phrase "rational and effective utilization" is better, because it suggests how the issue touches everybody and does not imply simple curtailment, an alarming vision in less industrialized countries. Using things better is a slow process, and the key is planning for the long term.

It's the oil villains. There's plenty of oil (or gas, or whatever), some say, but OPEC, or Exxon, or Shell, or all of them together conspire against us. To be sure, there's enough for a few decades, at increasing costs, but what then? The oil companies seem to be derivative rather than primary villains as they exploit the present situation.

The solution is biomass. Selectively useful, and sometimes an environmental benefit besides (as in energy from urban wastes), biomass brings the hazard of ecological collapse through overuse. Plato said that "contemporary Attica may be accurately described as a mere relic of the original country . . . what remains of her substance is like the skeleton of a body emaciated by disease . . . All the rich, soft soil has molted away, leaving a country of skin and bones." The Greeks (and Romans) had cut down the trees for firewood. Afterward, they introduced goats onto the land, completing the ruin, and so the Mediterranean littoral remains. This tragedy is now being repeated in India and elsewhere.

The corn required to replace 1 percent of U.S. gasoline with alcohol would provide 2,000 food calories per day to 10 to 20 million people, depending on the distillation technology. We should do something about automobiles, but not that.

The solution is other kinds of solar. The prospects are good, especially for low-temperature hot water and photovoltaic devices, both for distributed and central-station power. Most of that is well in the future, which is no reason to despair, but no reason to expect it tomorrow.

Controlled fusion is just around the corner. The science looks good, and certainly very interesting, but the technological and engineering problems of a practical reactor are still immense, and success is still uncertain.

There's lots of coal (and oil shale and tar sands). Most of the coal is in the United States, the USSR, and China, which is not reassuring to many countries. Remember also the environmental caveat stated earlier. But the rush for temporary, easy solutions tempts government and industry planners throughout the world to virtually ignore the long-term climatological dangers, or to dismiss them as unconfirmed, even unreal. But the problem presses because the fundamental changes that would constitute a remedy take many decades.

Nuclear power can/cannot save us. The superficial debate sometimes proceeds with the clarity, grace, and intelligence of a duel in the dark with chain saws. I will only remark that the exaggerations and misunderstandings so easily offered and accepted show that much of the nuclear debate is but symptomatic of a much deeper societal debate about more technology or less, centralized versus decentralized, and appropriate versus inappropriate, with many groups defining these terms to suit their own social or political aims.

These reflections suggest that the best long-term

Experts are likely to be attracted by the resources and ambiance of leading universities, but these institutions often exhibit disciplinary overspecialization in direct relation to their prestige.

global energy strategy (hence also for the United States, as a principal consumer) is quite different from what is being practiced. The industrialized countries should begin a determined program to permanently reduce their use of all carbonaceous fuels — coal, oil, and gas — via a combination of more rational and efficient energy use and a gradual shift to solar and nuclear "alternative" energy resources. That would leave more resources available for less-industrialized countries as they pass through the critical transition stage toward a similar nonfossil future. Many environmental, political, and social benefits would accompany such an action, which would require a degree of international and goodwill hitherto unseen.

What did we learn from this analysis?

☐ We did reach the forefront of the problem, perhaps uneasy to find it so near.

☐ Although simplistic opinions exist, there is no need to pander to them.

☐ Progress involves integrating science, technology, politics, history, and values.

☐ Solving the energy problem is not the same as solving problems in energy. A problem in energy is something already set up for a fairly clear answer, usually technological. But the energy problem transcends simple problem solving, being a combined sociotechnological condition we prefer not to have, or having, we wish to ameliorate. This egregious semantic error infests many other so-called problems too, such as the environmental problem.

☐ We found selective inattention, disparate time perspectives, and other problems; they cannot be disentangled.

Another example of selective inattention involves energy in a different way. Consider our national laboratories such as Oak Ridge and Argonne. One might naively expect that in an orderly family, the largest and strongest members would play a central role in developing new options for the largest and most complex problems. But what happens, or more precisely, is permitted to happen? Take the Oak Ridge National Laboratory, surely a place to work on energy in all its broader aspects. Until about 1973, such ideas had occurred to few of its staff and to none of its Washington patrons. Apart from activity in the basic sciences, which has some bearing on these matters, the laboratory worked not on the broad questions of energy but mainly on specific nuclear-reactor tasks. Attempts were made in 1970 and 1971 to broaden both the capabilities and roles of the national laboratories and the Atomic Energy Commission to include the now-recognized holistic concepts of energy and environmental quality, but

this precipitated prompt and blunt counteraction by the Atomic Energy Commission and the Congressional Joint Committee on Atomic Energy. It also delayed effective work on these matters by about five years and set back conceptual understanding even more. We still suffer from the legacy. Those attitudes have limited the competence, and hence the effectiveness, of the national laboratories.

Time Perspectives

If everyone stated how long their proposed cure to complex problems was supposed to be effective, the debate would be greatly clarified. We have many time perspectives involving economics, politics, technological innovation, technological obsolescence, environmental destruction (or reconstruction), and resource depletion, to name a few. We saw briefly how attention to different time perspectives often leads to conflicting energy decisions.

In most business sectors, expected return on investments involves time perspectives of only a few years. The pressure of elections leads to a similar outlook in the political sector, a myopia that is occasionally moderated by some politicians' sense of history. However, it takes 20 to 30 years, often longer, to develop and deploy large new technological systems such as the automobile and nuclear power. We live in the future of 20 years ago, when coal research was virtually ignored, and now call too quickly for benefits from that neglected art.

Several even longer time perspectives are important. The time to deplete a particular energy resource should exceed the time needed to develop and deploy alternatives or to adjust to a social and technological position of doing without. The urban and industrial infrastructures of civilizations heavily influence their energy use. Many disputes of exploitation vis-à-vis environmental preservation, and even the recently reinvigorated theological debate of dominion vis-à-vis stewardship over nature, can be described in terms of different time perspectives and the often-antagonistic responses.

Economic discounting will not resolve the question of disparate time perspectives, nor will the decision analysts' "indifference functions" do so, except in very simple cases. The difficulty is that as times stretch out, the populations of payers and benefiters diverge, and one must seek some underlying, persistent social consensus. Also, particular circumstances can alter discount rates drastically. "My kingdom for a horse," cried Richard III in 1472 at the Battle of Bosworth. His need was pressing.

Disparate time perspectives combined with selective inattention can lead to bizarre political results. A clear example is the approach of the United States in preparing for the World Environmental Conference in Stockholm in 1972. The National Academy of Sciences convened a group of its members and outside experts to consider the U.S. Conference position. The United States had called for environmental improvements requiring more expensive industrial processes — for example, to capture pollutants and not just let them go. During the group's deliberations, it was suggested, among other things, that the most pressing problems of developing countries were not related to dying at 55 or 60 from cancer-causing pollution, but rather to dying at age 15 from malnutrition, schistosomiasis, malaria, or tuberculosis. The developing nations are poor. If the U.S. wants higher global environmental quality, it should be willing to assist developing countries in that effort with foreign aid.

This point of view, which at first fell upon startled ears, was, after a while, accepted. A draft U.S. position paper was commissioned and duly appeared. But as soon as it reached higher administrative levels, it was torn to shreds. A quite different paper was produced by different writers, and Secretary of State William Rogers was sent to Stockholm to state categorically that global environmental problems and U.S. foreign aid had no connection.

Disciplines and Their Children

"Disciplinary reductionism" and "spurious holism" are two traits that often appear as opposite sides of selective inattention. Like Scylla and Charybdis, those hazards of Greek mythology, we are supposed to steer a course between the two extremes, but we can run afoul of both simultaneously.

We classify knowledge into intellectual disciplines such as physics, mathematics, and biology. Like politics, these disciplines exemplify the art of the doable. They are valuable, even indispensible, but socially contrived.

Professional disciplines are like people: they are born; occasionally they die. They form societies to assist in their nourishment. They show a strong sense of self-awareness by drawing logical

Civilizations grow and collapse partly as a result of selective attention or inattention, a combination of chance and social purpose.

peripheries and declaring that what exists inside their "field" is part of the discipline and what is outside belongs elsewhere.

Disciplines grow up and have children, called subdisciplines, which also later become disciplines, as physics became high-energy physics, then plasma physics, and so forth. Adam the generalist becomes Adam Smith the economist.

Analysis is easier than synthesis, so this disciplinary reductionism is easier than reintegrative holism. Artificial disciplinary boundaries limit social views. Economics and social sciences are good examples, where large areas such as no-growth concepts and ethics, respectively, were ignored until very recently.

Disciplines are the tools for solving problems, but sometimes we mistake the tools for what was to have been made with them, the scaffolding for the final structure. The ground of knowledge and wisdom upon which the civilization is based becomes unevenly covered with disciplinary structures according to fashion, convenience, and the perception of reward. This pattern and the actual needs of the civilization may not correspond.

So we need holism, which brings with it the danger of spurious holism, the opposite of reductionism, but selective inattention all the same. We recognize it easily in some religions, in which a particular set of axioms is tacitly assumed or even declared necessary and sufficient, and all society is bent to their application. Examples are the Catholic Church, especially before the Protestant Reformation, and some aspects of the Reformation itself; for example, Calvin's ordering of how the world should run henceforth. But we see it also in secular political movements. German National Socialism demanded and Soviet Communism demands obedience to systems that are themselves quasi-theologies, putting everything in its logical place. The difficulty with such systems is that if something serious goes wrong, their pool of corrective talent is very shallow.

Both extremes of selective inattention can occur simultaneously, in some self-reinforcing client-patron relationships, for example. If the client, say a division of a national laboratory, receives support from a governmental department, its disciplinary excellence imparts a good image to the patron, and both gain prestige and support. That is fine. The perversion consists of taking a short mental step to the "looking-good" syndrome, where the principal

Universities stimulate the intellectual attitudes of their students, but not always directly; professors are rewarded more for research than for excellence in teaching.

Wage Stability disagreed, and the White House Regulatory Assessment Review Group (RARG) wrote a sharp critique, presenting its own analysis, which included an epidemiological model, and reminding the EPA that White House suggestions were not to be dismissed lightly. Some of this was reported in *Science*. But what *Science*, the EPA, and the report writers never realized was that the RARG analysis was so badly in error that it even predicted a maximum damage effect at zero-pollutant concentration. This and other errors were pointed out to the EPA laboratory and the Washington authorities before final decisions were made. All chose to ignore this outside interference to the extent of not even responding to communications; the RARG recommendations prevailed. The point is not what the final ozone standards should have been, but rather the selective inattention for mutual security.

aim is cosmetic. For mutual protection, the client and patron either unwittingly or intentionally imagine that they understand the problem — the option-space — and what needs to be done, and then by selective inattention ignore outside suggestions and sometimes suppress them with sprightly and eventually geriatric vigor. Our national laboratories and their patrons, governmental departments, are susceptible to this disease.

A precise example involves the setting of ozone standards in 1978. The Environmental Protection Agency (EPA) recommended a particular maximum level of photochemical oxidants, mainly ozone (0.1 parts per million, with various short-term exceptions). But the president's Council on Price and

Maximizing and Minimizing Information Flow

Control over the flow of information is related to selective attention and inattention. In colleges and universities, the principle of free information flow is so commonly accepted as to go virtually unnoticed. Sometimes that leads to information overload and an inadvertently high noise level, inevitable occupational miseries. In the lands of bureaucracy and power politics, however, things are different. There knowledge is power: if I know something essential to your well-being that you don't know, then I have power over you. This power can be from knowledge of allocations, bureaucratic channels for getting approval, or whatever. This amounts to selectively

minimizing the flow of information, and, alternatively, to maximizing the flow of noise.

It sometimes works like this. Responding to some complex sociotechnological issue with much conflicting information, someone in a position of authority calls for a study to address the questions afresh, anew, or again. So our heroes in academia, industria, national laboratoria, and foundatia go to work, carefully listing the facts and perceptions pro and con in their report. What happens? The sponsor has a prior opinion and no intention of changing it. All he or she does is run quickly through the report, select passages and views that support the preconception, and then announce what the evidence has incontrovertibly shown; the rest is ignored. If the report is thorough, bulky, and hard to read — qualities that describe what many call academic excellence — the probability of effective public counterassessment is small. If, alas, the report is clear, concise, and not supportive of the sponsor's intent, it can be ignored. Besides, it is possible to judge in advance what many assessment groups are likely to produce and to select accordingly.

So the amount of information, the degree of polarization, and the irresolution of many issues grow. Everything becomes painted black or white, and the call goes out for more studies, upon which the antagonists feed afresh with selective inattention.

Lessons from History

These difficulties are not new but our ability to exploit unwisdom grows, and in this relatively closed world, the consequences of unwisdom are severe — one cannot just walk away and start afresh.

The Protestant Reformation was a time of much intellectual and spiritual transition. A grand debate arose about whether it was proper to mine the earth, similar to today's questions about technology in general. Agricola, in his great treatise *De Re Metallica*, summarized the arguments up to A.D. 1550, taking up these matters as the first priority. He quotes, among others, Pliny from the first century:

Iron is used not only in hand-to-hand fighting, but also to form the winged missiles of war: sometimes for hurling-engines, sometimes for lances, sometimes even for arrows. I look upon it as the most deadly fruit of human ingenuity. For to bring Death to men more quickly we had given wings to iron and taught it to fly.

Then he replies by writing of the benefits of metals in making ploughs and many other useful tools, beginning one philosophical passage with this:

In the first place, then, those who speak ill of the metals and refuse to make use of them do not see that they accuse and condemn as wicked the Creator Himself, when they assert that He fashioned some things vainly and without good cause, and thus regard Him as the Author of evils: which opinion is certainly not worthy of pious and sensible men.

Regarding overexploitation of resources, Peter Rideman, in another eloquent passage from the same period, wrote:

Now, however, as hath been said, created things which are too high for man to draw within his grasp and collect, such as the sun with the whole course of the heavens, day, air and such like, show that not they alone, but all other created things are likewise made common to man. That they have thus remained and are not possessed by man is due to their being too high for him to bring under his power; otherwise, so evil had he become through wrong taking, he would have drawn them to himself as well as the rest and made them his property.

Examples from more recent history show the need for more effective international organizations. In addition to global environmental and energy problems, consider multinational corporations. Many of them, it is said, oppress the less-industrialized countries, and calls go out to abolish them, or to nationalize their international tendrils. I believe that a useful parallel can be made with the multi*state* corporations of Vanderbilt, Rockefeller, Gould, and others in this country a century ago, with which the industrialists enriched themselves and some states at the expense of others. Why did so many of them incorporate in Delaware? Why do so many ships now register in Greece, Liberia, and Panama? The reasons are similar. The cure for the United States was to make the federal government appropriately strong, in the full realization that what was needed was to control the corporations. Their beneficial activities became more generally diffused, not only among states, but also to reduce the startling disparities within states. This should not be interpreted as a standard defense of the multinational corporations, or a statement that they can save the world if only they are controlled a bit more. Rather, it is a demonstration of the available option-space.

Universities stimulate the intellectual attitudes of their students, but not always directly: professors are rewarded more for research than for excellence in teaching.

Weaving an Educational Fabric

Everything so far has supported the thesis that societies — whole civilizations — get into trouble by not paying attention to their problems. Or, if they do pay attention, they do so carelessly, even perversely. Two key words in ameliorating this problem are reintegration and education.

Educational institutions often exhibit disciplinary overspecialization in direct relation to their prestige. One reason is that they often mistake disciplinary depth for the entire intellectual forefront. One is deep, the other broad. Another, more pragmatic reason is that the best experts on any fashionable topic are likely to be attracted by the resources and intellectual ambiance of a leading university. The more prestigious the place and the enterprise, the better are the chances of support for the expert. The logic is circular, leading to reinforcement of the discipline and its reputation.

The flow of intelligent young people through the university nourishes it vicariously, distinguishes it from national research laboratories, and saves it from many of their troubles. The university in turn stimulates the intellectual attitudes of its students, but not always directly: professors are rewarded more for research than for excellence in teaching. One result is that ideas of disciplinary supremacy attract good students, leaving too few prepared for the real complexities of life. But some creative students react oppositely and reject the educational system altogether. The postgraduate idea of "continuing education" also suffers: those in the outside world have seen life as it is, not as separate disciplines. The net effect is that the university interacts more weakly with outside sectors of society. (This would appear to lend some beneficial detachment to the university, except that strong university-patron relationships cause some of the problems in the first place.)

Disciplinary organization of knowledge is much too useful to dismiss, however; the challenge is to blend it with other things. M.I.T.—the university, or "institute," I call home — has avoided some of these difficulties in several ways. It works on the principle that income, as far as possible, goes into one pot. Therefore, well-funded activities such as controlled fusion and biomedical research help support the humanities and the arts through the general institute overhead. This facilitates many interdisciplinary activities that would otherwise be difficult to support. M.I.T. has some 24 departments and a similar number of "interdepartments" called laboratories, centers, and so on. If the departments are the warp of the fabric, then the interdepartments are the woof of it. This leads to beneficial mobility of people and ideas because they are not limited to one-dimensional motion along a single disciplinary thread. Observing this success, I conclude that three conditions for stability are required:

- ☐ Contributions in both sectors, instead of just one, must be adequately rewarded.
- ☐ Departments must have powers not usually possessed by interdepartments: curriculum control, admission, and granting of degrees, for instance.
- ☐ Similarly, interdepartments need their own relatively exclusive powers such as flexibility, funding for timely programs, and wide programmatic latitude.

But there are some destabilizing tendencies in such arrangements to which university administrators must be attentive. Faculty and students often desert a sick department, whereupon it wanes further. If the department is necessary to the institution, the

Trusting overmuch in organization, we find ourselves gummed to death by a horde of intellectually toothless mice, some of whom we trained.

administration must act positively. An overly aggressive or possessive department or interdepartment can threaten the existence of other groups, thereby causing noncooperation and later systemic weakness. This can take several forms. One is the group that tries to be both department and interdepartment, thereby making itself more or less independent in the pursuit of its excellence. By taking out both rows and columns, it simplifies but weakens the matrix.

Educating for Wisdom

What is the value of education? On one hand, consider modern advocates of economic utility such as Professors Richard Freeman of Harvard and J. Herbert Hollomon of M.I.T.:

For decades, the American higher-educational system has provided individuals with training and education promising high earnings and occupational status. With a bull market, there was little incentive to examine the value of college education carefully: whatever it was that was being taught was paying off in good jobs for graduates . . . [But] *we have now (1975) arrived at a point where growing numbers of people may be destined to remain underemployed or — by implication — overeducated . . . College Placement Council data show a decrease of 23 percent in the real starting pay for men with social-science or humanities degrees, a fall of 21 percent in the real pay for beginning B.S. mathematics majors, and of 17 percent for beginning electrical engineers with doctorates. Declines in real rates of pay have not been experienced by other workers and constitute a sharp break with past patterns of change.*

But such advocates are not unmindful of possible adverse social consequences. Freeman speaks of the dangers of "a sharply reduced role for investment in human capital as a route for economic growth, with possible effects on the long-term increase in productivity and income."

On the other side, we have John Stuart Mill, who viewed education as one generation passing on civilization to the next — "preservation of the nöosphere," to use Teilhard de Chardin's phrase. It prepares the student for later wisdom, not just for earning a living. The first approach seems a little too objective and the second suspiciously fuzzy.

An example from history is Lawrence Stone's eloquent account of some remarkable events and their consequences. In the mid-1500s, England became relatively prosperous. The Protestant Reformation convinced the English that everyone should be able to read and write, so an educational ethic grew. Village priests and curates doubled as teachers, supported not only by the church but by progressive-minded merchants and others. This educational flowering extended through all classes and continued until the English Civil War of the 1640s. According to Stone, well over 50 percent of the general population of London could read and write by the early 1600s; a similar fraction of the members of Parliament had attended a university or its equivalent. About 2.5 percent of college-age children attended college, a small fraction by modern standards but not to be reached again in England until the 1930s. These events explain the flowering of literature in the later sixteenth and early seventeenth centuries, and illustrate for what audience Shakespeare, Milton, and others wrote their works: they wrote for the people of London and England.

What was the result? Although mercantilism was growing, neither government nor commerce could absorb the mass of educated young people in positions and at salaries they thought commensurate with their education. Thus arose the "overeducated and underemployed" phenomenon described by Freeman and Hollomon. Many of these young graduates turned with reluctance and disillusionment to the one occupation still open and fashionable — education itself. There, Stone writes, lay a prime cause of the English Civil War: the teachers brought the country to restless discontent. The validity of this is borne out by the report of a special commission examining the causes of the war, which laid substantial blame on an overeducated and discontented populace. Free education was abolished, and parents that wanted their children educated had to hire someone to do it. This decision stimulated the formation of English private schools (perversely called "public").

Fortunately, the story does not end there. The educational momentum carried England from its relatively primitive state in the early 1500s into literary, economic, and scientific dominance. The English agricultural revolution of the early 1700s, and the Industrial Revolution that followed soon after, depended upon the general public's ability to read, write, and count. This early enthusiasm for education is evidenced by the Puritans, who established the New England colonies: Boston was founded in 1630 and Harvard College in 1636.

This history contains lessons for today. The danger of dissent in people overtrained and underwised is real. Nevertheless, education leads to societal advances unforeseen by the original teachers. The mistake was to indoctrinate people into expecting unreal, magical, and inappropriate rewards. So J. S. Mill and others appear to describe better what education is for.

All this bears on policy for higher education. Most university students do not specialize in science or engineering. Their nonspecialization is reasonable, but their almost total ignorance of the technological-scientific subworld now shaping their everyday lives is *un*reasonable. Academic departments, in reinforcing disciplinary excellence, see little reward in correcting this aberration.

These issues are more easily resolved after considering the proper time for engineering and applied-science education. Two opposing views of undergraduate curriculum contend: specialization first, and generalization first. Alas, the educational system currently leans toward the former. Disciplinary bias, the belief that an engineer with even minimal training is good for something, and the fear that a generalist is useless, combine to produce engineers who are relative technicians, less aware of social issues than the general public. Many of my professional colleagues do not understand much about the nuclear-power debate, for example, let alone the cultural and historical issues behind it.

The opposite approach, I believe, would be better. It is happening anyway, and the educational community should recognize it. People are natural generalists — that they are generalists before they are specialists, few can deny — and the four-year college education is more and more designed for popular consumption. Combining this trend with the fact that many technology-based companies demand advanced degrees (or equivalents) as the professional norm, it would make sense to shift engineering specialization into graduate years. Undergraduate engineering could then become "pre-engineering," ultimately producing broad new curricula for better equipping students to face the interactive problems of science, technology, and society.

Continued on page 67

Modeling: Selective Attention Institutionalized

by Sergio Koreisha
and Robert Stobaugh

Estimates for the price elasticity of crude oil supply

Study	Estimate
Kennedy-Houthakker World-Oil Model:	
"Pessimistic" case	.15
"Optimistic" case	.50
M.I.T. Study (Erickson-Span Model)	.87
Project Independence	.78

The decisions of policymakers are increasingly shaped by experts, and the advice of experts, in turn, is often determined by the models they employ. Although the outputs of a model presumably tell consultant and client how to implement agreed-upon values with rationality and efficiency, such results are highly sensitive to the realism — or lack of it — inherent in the model's formulation.

The energy situation is a case in point. Optimistic forecasts of influential experts in government, industry, and academia have helped policymakers avoid pressing for unpopular but necessary measures to alleviate the crisis. On the basis of such projections, administration officials in the early 1970s believed that energy prices would fall. In November 1974, after release of the model-dependent Project Independence report, an administration official was quoted by *The New York Times* as saying, "We expect oil prices to level out at between $4 and $6 a barrel." At the same time, OPEC prices were approaching $10 a barrel. In January 1975, Secretary of State Henry Kissinger said that new discoveries of oil as well as other sources of energy would make it "increasingly difficult for the cartel to operate," and the effects of these discoveries would be felt "within two to three years."

Compromises

By definition, models are compromises between reality and manageability and are thus of limited usefulness. The formulation of models requires assumptions about processes relevant to the phenomenon being studied. Consider some typical assumptions by builders of energy models:

☐ The market is competitive.
☐ Market responses to price changes can be described by specific mathematical equations.
☐ Political and institutional factors, although important, can be overlooked.

Ironically, political and institutional considerations dominate energy policy. These factors were responsible for the oil embargo of 1973, and they remain the most important elements of the "visible hand" that determines the price of a barrel of oil. Yet consider the following qualifications, typical of many energy studies, from the M.I.T. Energy Self-Sufficiency Study of 1974: "Behind every energy bottleneck and in every future decision stand serious societal issues — nuclear-power-plant safety, environmental protection, and many others. Such issues, though both appropriate and important to the debate now in progress throughout the nation, are beyond the scope of this report."

These assumptions, of course, can influence the results of a model. For example, this same M.I.T. study concluded that the United States could be energy self-sufficient by 1980. However, the model included some grossly exaggerated assumptions about energy "elasticities" to indicate that the United States could meet its energy demand from domestic sources. [A price elasticity of demand for oil of 0.5 means that if prices rise (fall) by 1 percent, demand will fall (rise) by 0.5 percent.] Similarly, although utility companies generally assume that there is an overwhelming economic advantage to nuclear capacity over coal, our recently published *Energy Future* study at the Harvard Business School convinced us that there is no scientific way to determine whether nuclear power generation is indeed more economical than coal.

Model builders generally can't agree on values even for commonly used statistics. For example, the figure above contains estimates for the price elasticity of the crude-oil supply from three different studies. Note the wide range of values: if the price of oil were to rise by 100 percent, the supply of oil in one case would increase by only 15 percent, while in another it would increase by 87 percent. The consequences of using different values — the "sensitivity" of the model — is illustrated in the figure on the facing page. Using four different sets of elasticity assumptions, Edward Fried and Charles Schultz (of the Brookings Institution) found that oil imports of the United States, Western Europe, and Japan could range from just below 16 million barrels per day to as much as 40 million barrels per day.

Alternative estimates of oil imports for the U.S., Western Europe, and Japan

Alternative Case I	Alternative Case II	Alternative Case III	Alternative Case IV
Estimate: 40.1 million barrels per day	Estimate: 22.5 million barrels per day	Estimate: 15.8 million barrels per day	Estimate: 27.5 million barrels per day
Assumes zero elasticity of demand and supply.	Project Independence Business-as-Usual Case.	Assumes greater elasticity of supplies and demand for oil in the U.S. as compared to Alternative II.	Assumes lower elasticity of supplies and demand for oil in the U.S. as compared to Alternative II.

An Art, Not a Science

We call a model's simplifying assumptions "red flags," items to which the model builder and users should pay special attention. There are five categories of red flags:

Exclusions. Any factor not included in the model is assumed to be relatively unimportant in affecting the conclusions.

In an econometric model, the builder seeks to measure the impact of one or more economic variables on another variable to predict future events or to explain an economic process. For example, a very simple econometric model could be constructed on the supposition that demand for oil this year depends solely on the price of oil. In such a case, the model builder assumes that natural gas prices have no effect on oil consumption. But higher natural gas prices could lead to increased oil consumption as consumers substitute oil for natural gas.

The Kennedy-Houthakker world oil model, for example, formulated in 1974 to predict long-run levels of oil production and consumption at various prices, excluded other energy sectors such as coal, natural gas, and nuclear. Consequently, the model could not quantify the effects on the oil market of major changes in other energy sectors. Also, the exclusion of factors such as sulfur levels in coal, different types of crude oil, and other kinds of fuel in some of the models in the Project Independence Evaluation System lead to conclusions that overstate our ability to shift to certain domestic fuel sources. Antipollution standards, for example, may preclude the use of coal with high sulfur levels.

Aggregation. Data on different subprocesses are often combined, or aggregated, as if they were one process to reduce the number of variables to manageable proportions, or simply because it is not possible or convenient to measure them separately. For example, American onshore and offshore oil production sectors clearly have different cost structures, yet many econometricians lump them together as though they constituted one large sector. This aggregation in one of the models in the M.I.T. Self-Sufficiency Study may have been the primary cause of the grossly overestimated price elasticity of .87 for the supply of oil, crucial to the model's indication that the United States could indeed meet its energy demands from internal sources. In Project Independence, variations in regional demand patterns were not accounted for in determining demand elasticities. Its conclusions, which may have been considered reasonable in the aggregate, were frequently misleading and impractical on a regional basis.

Range. The data in a forecast equation are calculated from observations from a range of prior experiences. If there is no change in the underlying economic behavior — if we stay within the range — then such data should be useful in making forecasts. But if data are used to make projections outside this range, then reliability deteriorates. As one moves further outside the range, the potential for error increases dramatically.

If an elasticity of 0.5 was found when the price of oil rose from $2.90 to $3.00 a barrel, one might assume with some confidence that the same elasticity would apply if the price of oil were to rise from $3.00 to $3.15. But there is no basis for assuming that the same elasticity would apply if the price were to rise from $3.00 to $10.00. It would be as though one were predicting the outcome of a marathon among runners whose track records were limited to the 100-yard dash. This occurred in the Kennedy-Houthakker world oil model, for example, where elasticities for various commodities estimated from data on the preembargo period (1962 to 1972) were used to predict the oil situation in the postembargo period. Data for price changes from $1.75 to $2.00 a barrel were used to estimate the effects of price changes from $2.00 to $10.00 a barrel.

Reversibility. If the elasticities used to make forecasts are derived during a demand period in which reduced prices are accompanied by increased consumption, then it is assumed that forecasts can also be made using these elasticities for periods when increased prices are expected to be followed by reduced consumption.

Consider the transition from coal to oil that occurred

in the United States in the 1960s and early 1970s. The price of oil actually declined (in constant dollars and in relation to other sources of energy) during many of these years. Oil consumption naturally increased, and other fuels, particularly coal, were displaced. However, other factors greatly influenced people's decisions to switch: oil is a cleaner fuel than coal; oil is easier and often cheaper to transport than coal; and the labor required to use oil is less. Although costly in some cases, the transition to oil was generally both rapid and smooth. In late 1973, the trend in oil prices was substantially reversed. Prices tripled and quadrupled virtually overnight, and there has been a continual upward shift in prices ever since.

The price elasticities of oil demand estimated for the Kennedy-Houthakker model were based on preembargo conditions and the reversibility assumption, with elasticities between .5 and 1.0. Thus, if oil prices increased by 10 percent, demand for oil products would decrease by 5 to 10 percent. Consequently, increases in consumption of other fuels would be necessary to satisfy even an overall reduced demand. In the United States, given the controversial status of nuclear power and the declining rate of discovery of natural gas, the most likely substitute for oil would be coal. But will we observe a commensurate increase in coal consumption in the coming years to satisfy the nation's energy demand? The answer is no. The transition from oil to coal will not be as simple as the transition from coal to oil. Environmental regulations, infrastructural constraints (particularly those of the railroads), and the cost and time required to retrofit equipment will prevent coal consumption from increasing very rapidly. (Reinstallation of the dismantled coal-handling equipment will be costly. A boiler designed to burn coal requires a larger firebox per unit of output than one designed to burn oil, so a boiler conversion from coal to oil can be done without loss of capacity. Conversion from oil to coal, on the other hand, will create substantial loss in capacity.) Oil consumption, therefore, could not decrease by as much and as quickly as forecast. The reversibility assumption is not justifiable in this case.

Time lag. The modeler is seldom able to estimate accurately the time required for a change in one variable, such as price, to achieve any given effect. Econometric models sometimes use "distributed lags" to account for slow adjustments to price changes such as retrofitting furnaces, making cars smaller, and changing commuting habits. However, in many cases there are not enough historical data to estimate how fast and effective the response is likely to be. This problem is sometimes handled using two elasticity estimates: one for short-term effects (often occurring in less than a year), and one to indicate long-term effects over many years.

Because they have to be assumed rather than derived, estimates of these lags generally involve considerable personal judgment. Kennedy and Houthakker assumed that the fuel effects predicted by their model would occcur by 1980 — that six years would be sufficient for long-run elasticities to apply. But the model was static: it was not constructed to trace the pattern of events leading to its conclusions. Project Independence estimated time lags much more formally than other models, but the integrating sector of the model was not dynamic. It presented solutions for given years but did not guarantee that the assumed time paths for changes in supply would be feasible or efficient. Project Independence modelers stated that "judgment and careful scrutiny are needed to assure that major shifts between periods do not occur or are not relevant to the conclusions being drawn."

Let the User Beware

Models should not be used blindly. Policymakers — that is, users — should require testing of the impact of various assumptions on a model's results. Models cannot quantify political and international factors; in the energy field, these factors dominate policy. A war in the Middle East or an overthrow of a key OPEC government can bring changes in oil prices and production almost overnight.

Predictions derived from energy models are imprecise because numbers are often based on subjective assumptions or simplifications. Furthermore, certain economic processes — and hence assumptions — may change and no longer be valid. Users should view precise figures with skepticism because of the immense uncertainties involved.

Policymakers must realize that a model can't capture all the details of a particular problem; its results should only be used in conjunction with the decision maker's own knowledge. A model provides insights, not answers; a model is not reality.

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Thoughtful Stewards of Creation

Why do civilizations decline, and why are we in trouble? We inflate and prop up dummy watchers of the sea to warn us of its storms, and imagine that appearance is reality itself. But as reality differs from our perceptions, we are swept away by a sea of events, and only consequential wreckage remains. We imagine we can solve class A problems with class B people, which cannot be done though 10 thousand of them are strapped together — any more than 10 thousand .9g rockets strapped together can get off the ground, let alone reach the moon. Trusting overmuch in organization, we find ourselves gummed to death by a horde of intellectually toothless bureaucratic mice, some of whom we trained.

These calamities need not happen, or at least their severity can be reduced, both in breadth and depth. I have made many proposals about energy and education, but plenty more await picking up, almost as pebbles on a beach.

For one thing, we can make better use of our global cultural heritage, which the doomsters see as narrower than it really is, so they get tunnel vision. Uniformitarians and those with no intellectual reflection from looking into the pool of different cultures and their rich histories unconsciously build toward that doom. In different places even now, and at different times even here, civilizations have had quite different attitudes involving time perspectives, environmental preservation, the unity of people and nature, conflict, and dominion vis-à-vis stewardship, by whatever names these things are called. Those differences tell us that the path is not unique or predestined.

Then we come to ethics — in particular, ideas of social justice, participation, and sustainability. In 1979, M.I.T. was host to the World Council of Churches' Conference on Faith, Science, and the Future, which dealt with these issues and many more. At that meeting of scientists, technologists, ethicists, theologians, and philosophers, each group discovered that others were worrying about the same issues but from different perspectives. Energy for the future becomes global justice and sustainability. Education: will it be for control, growth, or liberation? The scientists and engineers often found themselves in the forefront of moral leadership, certainly more often than many theologians and social critics expected, a discovery that left both sides constructively uneasy. Institutions such as M.I.T. cannot put aside their responsibilities, even though the implied tasks are difficult in their scope and commonality.

What attitudes do we bring to this work, a renaissance and reformation combined? The Stoics had four: *fortitias, justitia, prudentia,* and *temperantia,* all of which derive from *caritas* — or, in its Elizabethan English meaning, charity. This gives the spirit for all the rest and tells us that our neighbor is everyone in both space and time, making us thoughtful stewards of creation, dedicating our work to the service and support of all, and telling us that strength appears not so much as bravery at noon in the middle of the street but in every person's example, individual honor, and dignity, even though none but God might ever see it. □

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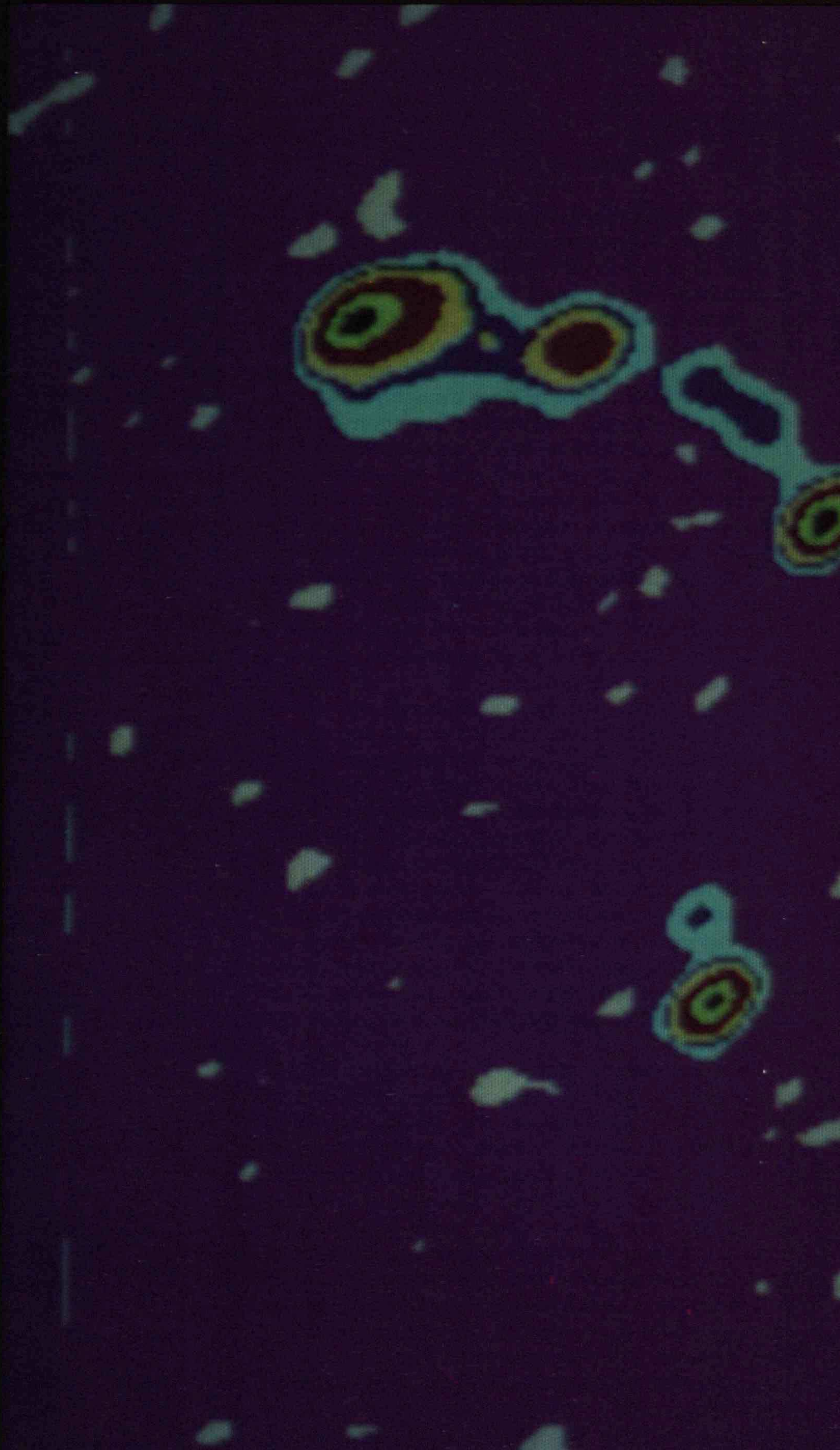


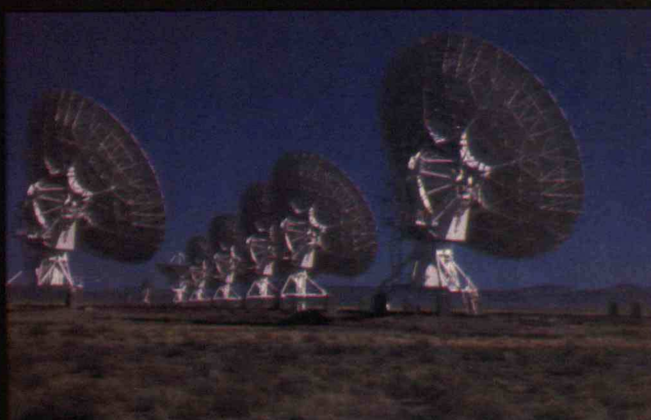
Right: A false-color map of 6-cm wavelength radio emission from the double quasar, 0957 + 561A,B, obtained with the Very Large Array radio telescope in February 1980. All photos courtesy of David H. Roberts.

Far right: The Very Large Array radio telescope near Albuquerque, New Mexico, consists of 27 individual antennas 25 meters in diameter. The parabolic dishes are spread over 40 kilometers in a giant Y.

Gravitational Lenses: From Einstein to the Double Quasar

by David H. Roberts and Bernard F. Burke

A mystifying pair of quasars turns out to be the double image of a single quasar seen through a gravitational lens: an almost invisible cluster of galaxies. By revealing such "hidden" matter, the lens effect opens a new window onto the cosmic darkness.



In the spring of 1919, the British astrophysicist Sir Arthur Eddington led an expedition to the island of Principe in the Gulf of Guinea to view a solar eclipse. This was no routine observation, for Eddington was determined to test Albert Einstein's 1916 prediction that light is deflected as it passes close to a massive object. According to Einstein's general theory of relativity, light just grazing the limb of the sun should be deflected through an angle of 1.75 seconds of arc, while according to Newton's theory of gravity, there should be no deflection. The question had been hotly debated in the scientific community. Eddington hoped to lay the issue to rest by comparing the positions of stars near the sun during a total solar eclipse to their positions when the sun was in a different part of the sky.

**Quasars,
being extraordinarily luminous and distant,
seem ideal objects against which
to see the effects of a
gravitational lens.**

On November 6, 1919, at an extraordinary joint meeting of the Royal Astronomical Society and the Royal Society of London, Astronomer Royal Frank Watson Dyson announced the eagerly awaited results: "There can be no doubt that (the data) confirm Einstein's prediction." The *Times* of London trumpeted the news: "Revolution in Science/ New Theory of the Universe/Newtonian Ideas Overthrown." Almost instantly, Albert Einstein became the most famous and respected scientist of his time.

Newton's theory, which had such a profound effect on science for over 200 years, describes the gravitational interaction of two objects by a force acting in a reference frame of fixed space and universal time. This force is proportional to the product of the masses of the two objects, and because the mass of a particle of light (the photon) is zero, light is not subject to gravitational forces. Thus, the path of a light ray past the sun is a straight line, and the apparent positions of stars would be the same with or without the sun nearby.

Einstein's general theory of relativity replaces the Newtonian description of fixed space and universal time with a system in which the very structure of space and time — "space-time" — is determined by the mass that is present. Space-time is "flat" in the absence of mass and becomes "curved" when mass is introduced. (Flat space-time corresponds to Einstein's special theory of relativity, whch deals with high velocities but not with gravitation.) Particles in curved space-time move along "straight lines" called geodesics, paths that correspond to the shortest distance between two points when measured in space and time simultaneously. When examined in space alone, these paths are curved — examples are the familiar parabolic path of a thrown ball and the elliptical orbits of the planets around the sun. Particles of zero mass such as the photon follow special paths, called null geodesics, which are also straight in space-time and curved in space. This means that the path of light passing near a massive body is bent, as was so dramatically verified by the 1919 eclipse observations.

Einstein's Universe

However stunning this result, the crowning glory of general relativity came during the next decade. Theories of the structure and evolution of the entire universe — "cosmologies" — developed from the general-relativistic description of gravitation, suggested that the universe is not static but must be undergoing an overall expansion or contraction. Observations in the early 1920s established that other galaxies are indeed moving away from us. In 1929, Edwin Hubble announced his discovery, subsequently known as Hubble's law, that the universe was expanding just as the general-relativistic cosmologies predicted — the velocity of recession of a galaxy increases linearly with its distance from our galaxy. The motion of a galaxy is detected from its effect on the light it emits. Each wavelength is "stretched" — that is, shifted to the red end of the spectrum — by an amount that increases with velocity, expressed in terms of the galaxy's "redshift" z. Thus, by virtue of Hubble's law, redshifts are measures of distances. The most distant galaxies known have redshifts z not much larger than one. With Hubble's discovery, general relativity was established as the correct way to describe gravitation on scales ranging from that of our own sun to that of the entire universe.

It went largely unnoticed in 1924 when O. Chwolson suggested that because light is bent when passing a massive body such as a star, such a body could act as a kind of lens. The appearance of an object would be distorted if its light rays passed close by another object on their way to Earth. In particular, a distant object could appear as a double image, with one image on either side of the intervening object, which acts as a gravitational lens. A decade later, Einstein calculated the likelihood of such a gravitational lens caused by one star in our galaxy affecting our view of another star behind it, and concluded that the chances of observing such an event were negligible.

There the matter rested until the development of radio astronomy in the 1950s pushed the observed edge of the universe out to much greater distances. The discovery of almost uncountable numbers of very distant sources of radio emission provided astronomers with far more objects against which to observe the effects of a gravitational lens. More recently, the idea was revived by William Press and James Gunn, who made an ingenious proposal to measure the total amount of matter in the universe by counting the number of distant radio sources distorted by the gravitational-lens effect. The attraction of this idea was that it would not be necessary to see an object to detect its presence; the lens effect would

The discovery of a double quasar presented a dilemma: was this a true "twin quasar," or was this the first gravitational double image?

give it away. Thus, even "dark" matter — material producing little or no light despite its large mass — could be detected. There may be a great deal of such virtually invisible matter that contributes significantly to the gravity of galaxies, clusters of galaxies, and the entire universe. Unfortunately, radio sources themselves often appear so complicated that it is difficult to sort out those that are distorted by a gravitational lens from those that were simply born distorted, so this technique has not yet yielded any information about dark mass in the universe.

Quasars: Beacons in the Cosmic Depths

In 1963, the prospects of finding gravitational lenses were brightened by the discovery of quasi-stellar objects (known as quasars or QSOs). The first quasars were discovered through their powerful radio emission. Although superficially they look like stars because they appear as points of light through an optical telescope, quasars soon revealed themselves to be quite extraordinary objects. Their energy outputs exceed those of entire galaxies, although they are only a millionth of a millionth as voluminous. And their distances from our galaxy are staggering: the largest quasar redshift known is $z = 3.53$ — far greater than the redshifts of the most distant galaxies. Because an object with such a large redshift is very far away, the light we see was emitted when the universe was much younger. So in addition to providing a view of the most distant parts of the universe, quasars enable us to study its ancient past.

By virtue of their extreme luminosities and distances, quasars provide astronomers with a unique opportunity to probe what lies between us and the outermost parts of the universe. Any diffuse gaseous material between Earth and a quasar will be detected because of the light it absorbs from the quasar's spectrum. Some quasars show just such absorption patterns in their spectra, and it is now known that virtually every high-redshift ($z > 2$) quasar possesses a rich absorption spectrum. Many astronomers believe that analysis of these absorption lines tells us the velocities, distances, numbers, and physical conditions of otherwise invisible galaxies lying between us and the distant quasars. To account for the observed spectra, galaxies must be far larger than they appear in optical photographs, an idea proposed before the observations for quite different reasons.

Quasars seem to be the ideal objects against which to observe the effects of a gravitational lens. Because they are extraordinarily luminous, they can be seen at the large distances required for there to be a reasonable likelihood of a lens-producing object lying along the line of sight. They are also pointlike, so the effects of lens distortion on their image should be easily recognizable. During the 1960s, calculations of the properties of gravitational-lens images were made, but apparently no one actually set out to find any.

The Double Quasar: True Twin or Two Images?

In the spring of 1979, Dennis Walsh, Robert Carswell, and Ray Weymann, working at the Steward Observatory of the University of Arizona, were systematically attempting to find optical objects near the positions of a number of radio sources that had been observed by Richard Porcas of the University of Manchester. They found that near the position of a radio source called 0957+561 were two starlike objects separated by only 6 seconds of arc — an angular distance equal to one-three-hundredth the diameter of the full moon. Still following the usual procedure, they used the 2.3-meter Steward telescope on Kitt Peak to obtain a spectrum for each object, assuming that one was probably a distant quasar associated with the radio source and the other a foreground star in our galaxy. To their amazement, the spectrum of each object bore the unmistakable signature of a quasar with redshift $z = 1.4$. Furthermore, except for the fact that the northernmost object was 30 percent brighter, the spectra were essentially identical. Subsequent observations showed that the two quasar spectra also had essentially identical absorption lines. Walsh, Carswell, and Weymann were thus faced with a dilemma: had they found an actual "twin quasar" — two very similar quasars close together in space — or were they seeing the first double image created by a gravitational lens?

The most direct proof that the double quasar was a gravitional-lens image would have been detection of the "lens" object, but various photographs showed nothing lying between the two quasar images. The sun was rapidly moving into that part of the sky, and the optical observing season ended without discovery of such an intervening object.

However, the gravitational-lens hypothesis provided a prediction that could be tested: general relativity says that the bending of light does not depend on its wavelength, so the double quasar should look the same at all wavelengths. When the news of the discovery reached the Massachusetts Institute of Technology, we, together with graduate student Perry Greenfield, decided that since the double quasar had been discovered because it was a radio source, it was natural to test the gravitational-lens hypothesis by observing it in the radio part of the spectrum. Because radio observations are not hampered by the bright daytime sky, we immediately requested time for a short observation of the double quasar using the only instrument in the U.S. capable of resolving two objects so close together, the Very Large Array radio telescope.

View Through the VLA

The Very Large Array (VLA) is a radio telescope built and operated by the National Radio Astronomy Observatory. Located on the Plain of St. Augustine about 100 miles southwest of Albuquerque, N.M., it consists of 27 individual antennas 25 meters in diameter spaced along a Y-shaped set of railroad tracks. Each arm of the Y is about 20 kilometers long and has 9 antennas. The VLA operates as a multielement interferometer, a radio telescope in which the output of each antenna is combined with that of every other antenna and the results analyzed in a central computer. The rotation of the Earth changes the position of the array with respect to the source under observation, producing new information for up to 12 hours. The result is a "radio picture" of the sky, with angular resolution equal to that of a single antenna 40 kilometers in diameter and the sensitivity of a single dish 130 meters in diameter. Using this instrument, astronomers can study the radio sky at a resolution at least as good as that of the best optical telescopes (about 1 second of arc) while retaining the sensitivity to reach the most distant parts of the universe.

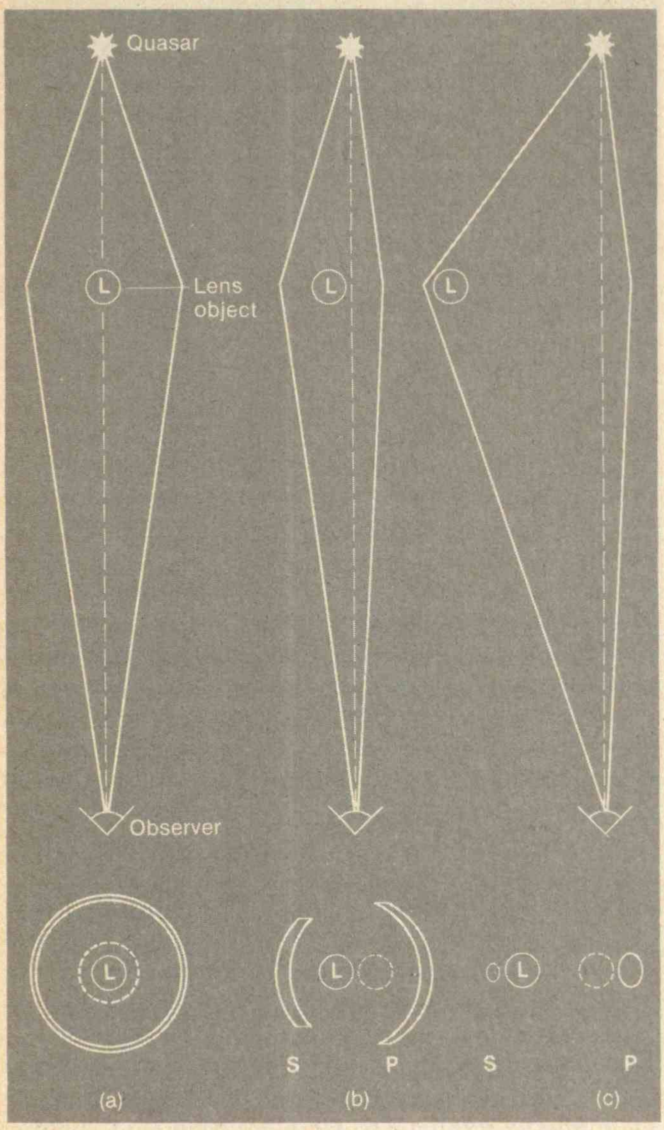
Construction of the VLA began in 1974 and the last antenna was assembled in the fall of 1979; the VLA was formally dedicated in October 1980. Throughout construction, limited time was available for astronomical observations with the partially finished array. When our M.I.T. group made its first observation of the double quasar in June 1979, only a partial array of 14 antennas was operating. The majority were located along the southwest arm of the Y, the most distant being 17 kilometers from the center of the array. We chose to observe at the VLA's most sensitive wavelength of 6 centimeters (with a resolution of 0.8 seconds of arc). We divided our observing time into eight scans spread over 12 hours, each scan consisting of 6 minutes on the double quasar and 3 minutes on a nearby calibration source. One scan was lost owing to an equipment failure, so the total time spent observing the double quasar was only 42 minutes. Because of this very limited observing time, the resulting radio map of the double quasar was relatively "noisy" but nonetheless superior to that obtainable with any other radio telescope.

The Point-Mass Model

The map showed two pointlike radio sources separated by 6.1 seconds of arc in a north-south direction (*see p. 76*). The radio positions of these objects were the same as the optical positions of the two quasars, and there could be no doubt that a double radio quasar was coincident with the double optical quasar. The north quasar (A) was about 20 percent brighter than the south quasar (B), which was not significantly different from the amount by which the optical A image was brighter than the optical B image. This was expected in the gravitational interpretation and was especially encouraging because the optical and radio wavelengths differed by a factor of 100,000. On the other hand, if there were two distinct quasars, there would be no reason to expect the brightness ratios to be the same at such different wavelengths.

However, there were additional sources in the radio map that had to be considered. A bright pair of extended sources (C and D) lay east of A, and a much weaker source (E) lay southwest of A. There were also very weak bridges joining D and E to A, and short extensions south of A and northeast of B, but these latter features were faint and not included in the analysis. A map also made at the 6-centimeter wavelength by Guy Pooley, Dennis Walsh, and colleagues on the 5-kilometer radio telescope in Cambridge, England, showed the same overall structures but with a resolution of 2 seconds of arc.

The first thing we had to determine was whether the "extra" radio sources C, D, and E were physi-



How a point-mass gravitational lens bends light traveling from a distant quasar to an observer on Earth *(top)*. The image seen by the observer. (The broken circle represents the quasar's position in the absence of a gravitational lens *(bottom)*. **a** The lens object is on the line of sight, and the observer sees a ringlike image. **b** The lens object is slightly off the line of sight. The observer sees two crescents — a primary image (P), and a secondary image (S). **c** The lens object is far off the object-observer line, and the secondary image is significantly displaced while the primary image is only slightly displaced.

cally related to the double quasar or whether they were just a chance superposition of foreground or background objects. Because radio astronomers have determined the numbers and brightnesses of radio sources, we were able to calculate the odds against such a superposition at about 300,000 to 1. This, together with the fact that the alignment of C, D, A, and E is very typical of radio sources associated with quasars, suggested very strongly that the extended radio emission was physically related to the double quasar.

The question then arose: could this complicated radio source be a gravitational image? The absence of direct optical evidence for a gravitational lens (such as a galaxy) lying between the A and B images suggested that any such object was small and "dark," so we first considered the simplest gravitational-lens model consistent with our information: a point mass. The imaging properties of a point-mass gravitational lens are fairly simple (*see left*). If the mass is exactly on the line from object to observer, the observer sees a ring, with the total brightness amplified by the lens effect. If the mass is slightly off the line of sight, the image becomes a pair of crescents of approximately equal brightness. In the case of a quasar, where the object being observed is small, the crescents will appear as point images. As the mass is moved farther off line, the brightnesses of the two images become progressively more unequal, the primary image lying close to the undeflected position of the object and the fainter secondary image lying just on the other side of the lens.

Except in the unlikely case of exact alignment, which yields a single ring, a point mass always produces two images of each object behind it. There is a simple rule relating the brightness of the two images to their angular separations from the lens, so even though there was no direct optical or radio evidence of a point-mass gravitational lens, we could use our observation of A and B to determine where such a mass must lie. That place is just 0.2 arc-seconds closer to B than to A, almost exactly midway between A and B. In other words, the quasar, unseen lens object, and observer are lined up almost exactly.

If the extended radio sources (C, D, and E) are indeed physically related to the double quasar, and the radio map is a gravitational double image caused by a point mass, then the images of the extended sources must also be doubled. Given the location of the mass, we could calculate that under these cir-

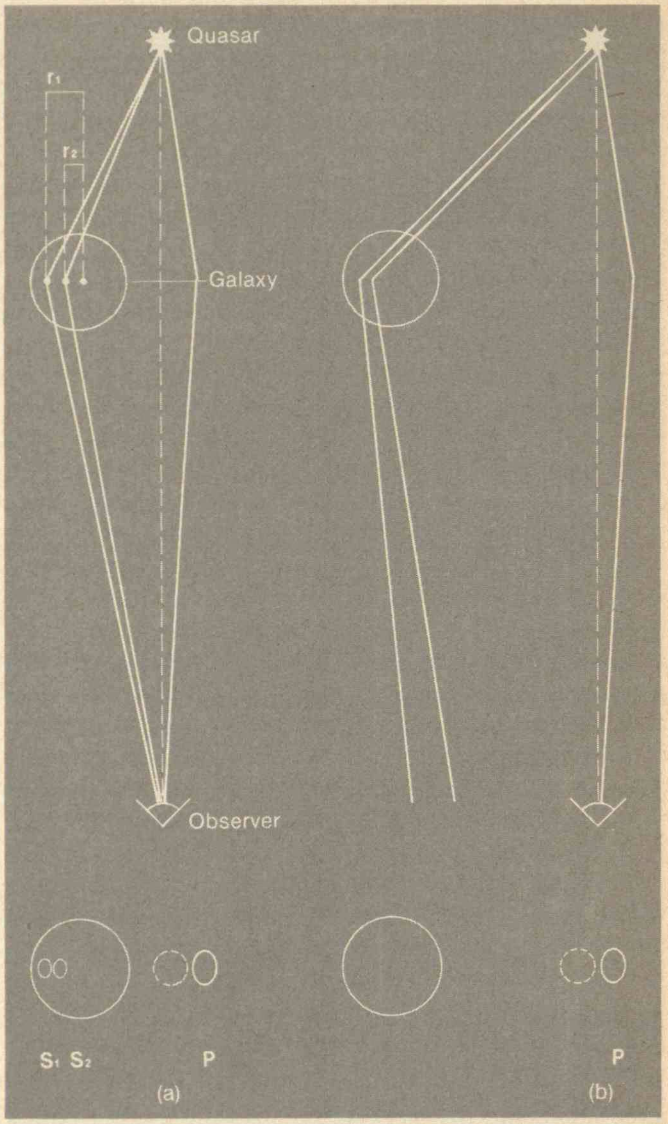
cumstances, the primary images C and D together would have a small secondary image about 2 seconds of arc northwest of B, and that this secondary image would be about 3 percent as bright as C and D together. But such an object would be too faint to be seen clearly in the map, and thus this model could not be ruled out.

Missing Images

With so much new information gained from only 42 minutes of observation, it was clear that a more complete observation on the VLA was warranted. Our primary objective was to search for a second image of C and D, and we also hoped that a more sensitive map would reveal the gravitational-lens object itself. Thus, in October 1979 we performed full 12-hour observations of the double quasar at both the original 6-centimeter wavelength and an additional 20-centimeter wavelength.

By this time, the VLA had 18 working antennas, most still on the southwest arm. This, plus the much longer observing time, allowed us to construct maps far superior to the one we obtained in June. The 20-centimeter-wavelength map also showed two point sources coincident with the optical quasars, but here A was 67 percent brighter than B, quite different from the 6-centimeter and optical-wavelength observations. The only way to account for this within the gravitational model was to assume that the radio quasar's brightness varied with time. In the model, the two light paths — from the quasar past the bending mass to the observer — are not the same length, so the two images A and B do not arrive simultaneously. If the ratio of the quasar's brightness at 6 and 20 centimeters is not constant because the quasar varies at one or both wavelengths, the ratios of the brightness of the two images could be different at the two wavelengths.

The 6-centimeter-wavelength map provided important new evidence about the gravitational-lens model for the double quasar (*see p. 73*). The resolution was improved over the June map by about 30 percent, and the sensitivity was better by a factor of three. The C, D, and E features of the June map were all verified, and A was 33 percent brighter than B. The bridge between A and the extended sources C and D now appeared clearly as a narrow jet from A toward D (the "A jet"). In addition, there was another, smaller "B jet" extending north from B



How an extended-mass gravitational lens, such as a galaxy, bends light *(top)*. The image seen by an observer on Earth *(bottom)*. **a** An extended mass somewhat off the line of sight causes the primary image to be displaced slightly. Light passing through the extended mass at each of two specific radii (r_1 and r_2) is bent through an angle such that it reaches the observer. The observer sees two secondary images (S_1 and S_2) shining through the extended mass. **b** The extended mass is so far off the object-observer line that there is no way light can be bent sufficiently to reach the observer. Consequently, the observer sees only the primary image.

which, although only 7 percent as bright as B, was definitely real.

No second image of C and D was present in either the 20-centimeter or 6-centimeter map to a significantly low level of brightness. This definitely ruled out a gravitational-lens model in which the intervening mass was a pointlike object lying almost midway between the A and B quasars.

Search for Alternatives

The lack of conclusive evidence that the double quasar was a gravitational image led us to consider the alternative that we were seeing two separate quasars. The discovery of a true twin or binary quasar would be even more astounding than finding a gravitational-lens image. Careful study of the quasars' interaction could tell us a great deal that we could learn no other way. In this interpretation, the two quasars appear so alike because of a common origin, similar physical properties, and similar evolution. The strongest argument against the twin-quasar interpretation came from the striking similarity of the absorption-line spectra of the two. The quasars are so far apart that a cloud of gas large enough to absorb light from both would be expected to do so at somewhat different wavelengths in the two quasars. The near-equality of the absorption spectra would then have to be coincidental, though not impossible.

Another possible explanation for the absence of a second image of C and D was that there *is* a gravitational lens, but it is not a point mass. In fact, the point-mass lens model, while simple to deal with, applied only to very small but heavy objects (such as a black hole with the mass of a galaxy, of which we presently have no example). On the other hand, the as-yet-unseen mass might be dark yet extended in size like a galaxy. In a galaxy, the mass is spread throughout a large volume, and light passing through it will be bent differently than light passing around it. More complicated gravitational imaging occurs for such extended mass distribution, with a single object being refracted into one primary image — still the one with the smallest bending — and zero, two, or even more secondary images (*see left*). What actually happens depends on the way in which the mass is distributed in the galaxy and on exactly how object, galaxy, and observer are lined up.

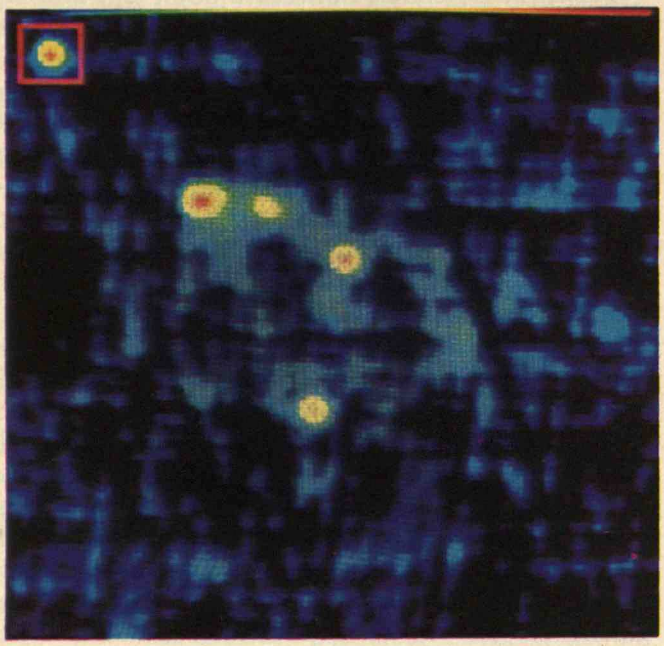
The basic difference between a point lens and an extended lens is that while the former can bend light through an arbitrarily large angle, the latter cannot. Consider the deflection of a beam of light passing through a galaxy at a distance r from the center. The angle of deflection is inversely proportional to r and directly proportional to the amount of mass contained in the cylinder of radius r with an axis that passes through the galaxy's center and that is aligned with the path of light. For a point mass, r can be arbitrarily small and still include all the mass, so any angle can be obtained. As a result, a point lens always produces two images. But an extended mass behaves differently. For any path through the galaxy, the mass in the cylinder is less than the total mass of the galaxy, and consequently the light is bent less than if the mass were concentrated in a point. Because the enclosed mass becomes very small as r approaches zero, there is a maximum angle through which a galaxy can bend light. As a result, a galaxy too far off the object-observer line will be unable to bend light enough to bring it to the observer as a secondary image. All that remains is the single primary image. In addition, there are always two distances r for every possible bending angle through the galaxy, so secondary images occur in pairs. Consequently, the total number of images formed by a gravitational lens is always odd (the secondary pair and the single primary, or the primary alone).

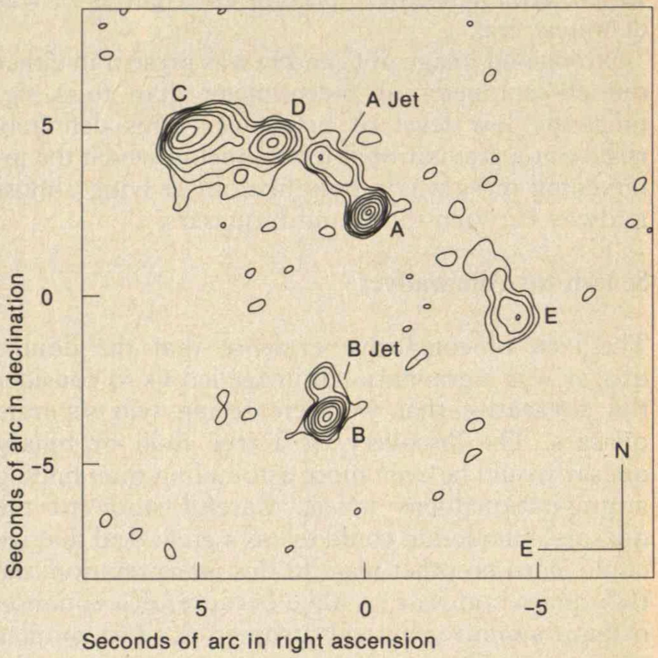
A revised gravitational-lens model incorporating an extended mass could account for the possibility that while A and B are two images of the same quasar, there need not be second images corresponding to C and D. This is because if the lens lies almost midway between A and B, it might be too far off the line from C and D to form secondary images.

But the new map provided other constraints — the two radio jets, which lay so close to the A and B quasars that they should have second images even if the lens is an extended galaxy. A second image of the A jet should also have been seen near the B quasar, pointing in a northeasterly direction, and an image of the B jet near the A quasar, also pointing slightly northeasterly. Each second image should have been bright enough to be easily seen, but neither was present. Thus, we concluded that even an extended mass such as a galaxy lying near the midpoint of A and B could not produce a gravitational image matching the radio map.

The double quasar 0957 + 561A,B as mapped at 6-cm wavelength by the Very Large Array radio telescope in June 1979. In this false-color display, red corresponds to the brightest parts of the map and blue to the faintest. (The box in the corner shows how a point source would appear in this observation.) The two unresolved sources are oriented north-south near the map's center. A is north of B (on the sky, if north is up, east is to the left).

Line drawing identifying parts of double quasar maps. On the sky, if north points up, east is to the left.





A Solution in Sight

Just as we prepared to publish these conclusions in the fall of 1979, there was a dramatic new development. Using the 200-inch Mt. Palomar optical telescope, Peter Young, James Gunn, and colleagues at the California Institite of Technology observed the double quasar with a new instrument called a charge-coupled device (CCD). Because the CCD can detect faint objects in the presence of a bright object, they were able to detect a giant elliptical galaxy centered about 1 arc-second north of the B quasar and extending about 2 arc-seconds in all directions. Previous observers had not found this galaxy because they had been blinded by the B quasar, which is about 10 times as bright as the galaxy. Measuring the redshift of the galaxy, the Caltech astronomers found it to lie halfway between the quasar and Earth. Thus the B quasar was shining through the galaxy, making the galaxy a very good candidate for the gravitational lens! They also found this galaxy to be the brightest member of a large cluster of galaxies, and pointed out that the cluster as a whole could play a role in bending the light.

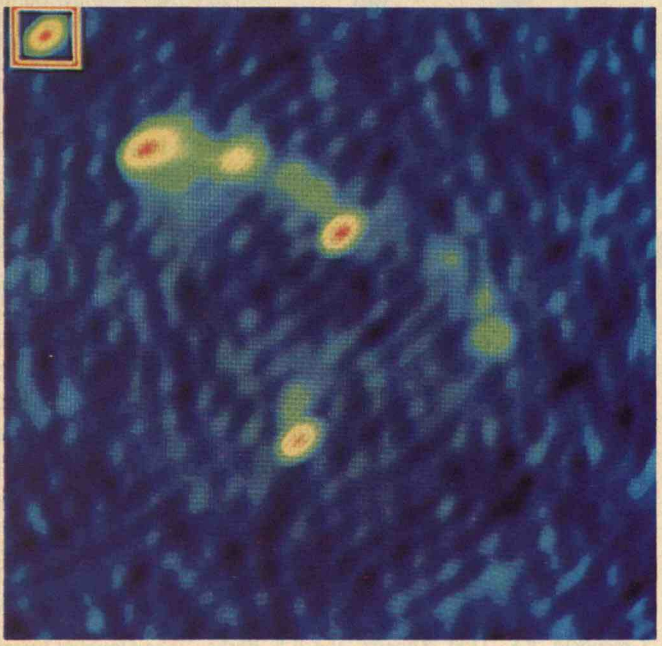
Young and his colleagues worked out the properties of an off-center, extended-galaxy gravitational lens and showed that it accounted naturally for the two most important facts about the double quasar — that A and B are almost equally bright, and that there are no second images of the extended radio lobes C and D. They realized that A and B can be of near-equal brightness even if the lens object is not midway between the two images. In their model, A is the almost undeflected primary image, while the secondary image B has been bent through a large angle. Although the A image is much farther from the galaxy than the B image, if the latter image is formed very close to that critical radius at which light rays are bent through the largest possible angle, the galaxy acts as an ordinary converging lens, amplifying the secondary image so that it can be almost as bright as the primary image, A. This arrangement of object, lens, and observer also explains why there are no second images of C or D: the original radio sources of which C and D are the primary images are too far off the galaxy-observer line to have second images.

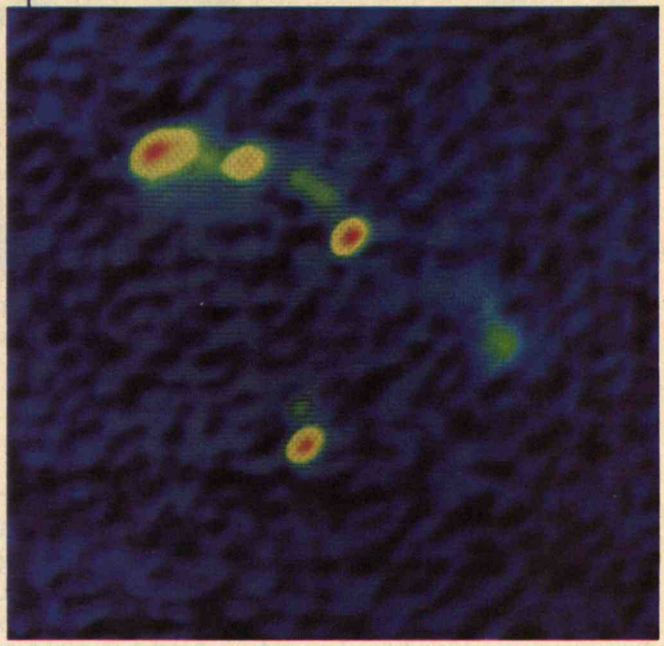
Red Herrings

The two radio jets provided another test and possible trouble for the off-center, extended-galaxy gravitational-lens model of the double quasar. The A jet should have at least one weak secondary image very near the B quasar. It seemed unlikely that the B jet itself was the second image of the A jet because it

The double quasar as mapped at 6-cm wavelength in October 1979. By this time, 18 of the VLA's 27 antennas were working. Objects C, D *(upper left)*, and E *(center right)* were verified, as were narrow extensions northeast of A (the A jet) and north of B (the B jet). No second images of C or D were found, ruling out a point-mass lens object lying halfway between A and B.

A 6-cm map of the double quasar obtained in February 1980. By this time, there were 22 working antennas. In this map, the B jet is resolved into a point source, G, with a position coincident with the nucleus of the lens galaxy. Comparisons of the brightnesses of G and B at 6-, 18- and 20-cm wavelengths suggested strongly that G is not a third quasar image but rather a radio source in the lens galaxy itself.





wasn't in quite the right place. The B jet could be a second image of C and D produced not by the extended mass distribution of the lens galaxy but rather by a dark point mass — a black hole — in its nucleus. (Evidence for such black holes in the nuclei of other giant elliptical galaxies has been found by Young, Wallace Sargent, and colleagues.) On the other hand, the B jet could simply be a radio source in the lens galaxy itself and not part of the gravitational image at all. Or the B jet could be the other secondary quasar image (remember, they come in pairs) required by the extended-mass model: the A quasar is the primary image and the B quasar is one secondary image, and in some plausible arrangements of quasar, galaxy, cluster of galaxies, and observer, the weaker secondary image would appear very close to the nucleus of the lens galaxy. And finally, if a better observation showed that the B jet was significantly north of the center of the proposed lens galaxy, it could be none of these things, and the whole model might have to be abandoned.

To test these ideas, we returned to the VLA in February 1980. By this time the array was substantially larger, with 22 working antennas, including several at significant distances down both the north and southeast arms. In addition, automatic rejection of poor data had been improved and observing conditions were ideal. The resulting 6-centimeter map was of substantially higher quality than that obtained the previous October (*see above, right*). Its most significant feature was the resolution of the B jet into a point source we called "G," with a position we measured accurately at 1.1 arc-seconds northeast of B. This was coincident with the position of the nucleus of the lens galaxy as it appeared in a superb optical photograph of the double quasar made on the University of Hawaii 2.2-meter telescope by Alan Stockton (who had independently discovered the lens galaxy). The simplest interpretation was that G is a small radio source in the lens galaxy and a red herring in the interpretation of the gravitational-lens image.

The possibility remained, though, that G was in fact the other secondary quasar image demanded by the extended-mass model of a gravitational lens. If G were this third image, the radio spectra of G and B would be similar. We had also made maps of the double quasar at 18- and 21-centimeter wavelengths, and these were now examined carefully for evidence of G. In both maps we found a small point source at the right place, and we were able to compare the brightness of G and B at 6-, 18-, and 20-centimeter wavelengths. The result was that B and G differed significantly, strongly suggesting that G is not the third quasar image but simply a radio source in the lens galaxy. (Of course, the third quasar image

may still be located near the nucleus of the lens galaxy, but it must contribute only a small part of the observed source G.)

The other possibility is that B itself contains both secondary images but that they are separated by such a small angle that they cannot be resolved by the VLA. However, very long baseline interferometry radio observations with 100 times the resolution of the VLA (but less sensitivity) made by Marc Gorenstein, Irwin Shapiro, and colleagues at M.I.T. have shown that if this is the case, the weaker of the two images is less than 5 percent as bright as the stronger one.

Promise

We have followed the twisted tale of the double quasar from its discovery to its unscrambling by a synthesis of optical and radio observations. Along the way, we have seen how the growth of the VLA yielded new information at each step. There is no longer any doubt that the double quasar 0957+561A,B and its complex radio emissions represent the gravitational double image of an ordinary quasar and its extended radio source. The imaging is far from simple, and some details are not yet certain. The third quasar image, which must be located near the B image, has yet to be found.

Further study may reveal information about the lensing galaxy and the cluster of galaxies to which it belongs. If we know the difference in the lengths of the light paths forming the A and B images, we can place strong constraints on the total mass of the cluster. The way to measure the difference in path lengths is to compare the two main images over time. From our VLA observations, we know the quasar's brightness is variable, so by observing changes in A and measuring the time delay before corresponding changes are observed in B, we will learn by how much the path lengths of the two images differ. We measure the brightness of A and B once a month at the VLA and expect to continue for several years. Similarly, Robert Wilson of the University College in London will be watching the double quasar with the International Ultraviolet Explorer satellite, which also works year-round. Wilson has already shown that the brightness ratio of A to B at ultraviolet wavelengths is consistent with measurements at other wavelengths in accordance with the general-relativistic model of a gravitational lens.

Successful measurement of the time delay would help solve one of the outstanding problems in astronomy, the question of the "missing mass" in clusters of galaxies. The random velocities of the individual galaxies are a measure of the total mass in a cluster, and it has long been known that the measured velocities of galaxies in nearby clusters correspond to masses 10 or 100 times as great as the total visible mass. If we are able to determine the amount of dark mass in this cluster from the observed image of the double quasar and the path-length difference between the A and B images, the gravitational-lens effect will begin to fulfill its promise as a probe of the universe.

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Bernard F. Burke is professor of physics at M.I.T., where he received his undergraduate and graduate degrees. **David H. Roberts** is assistant professor of physics at Brandeis University; his Ph.D. is from Stanford University.

Black Holes and Hot Bodies

Complete the word definitions; then enter the appropriate letters in the diagram to complete a quotation from an early article on cosmology.

The first letters of the defined words give the author and title from which the quotation is taken. Black squares in the diagram indicate ends of words; if there is no black square at the right end of the diagram, the word continues on the next line.

The solution will be in the next issue, when another of Mr. Forsberg's puzzles will also appear. Readers are invited to comment—and to suggest favorite texts for future puzzles.

1 X	2 H	3 L	4 T	■	5 E	6 G	7 J	8 N	9 C	10 B	11 O	■	12 A	13 M	14 P	15 E	16 G	17 J	18 O	19 V	20 F	■	21 F	22 G	■	■
23 J	24 O	■	25 J	26 V	27 R	■	28 R	■	29 G	30 L	31 U	32 E	■	33 K	34 A	35 H	36 N	37 O	38 R	39 E	40 C	■	41 I	42 O	43 E	■
44 A	45 P	46 X	47 F	■	48 W	49 C	50 R	■	51 T	52 R	53 F	54 L	■	55 S	56 P	57 G	■	58 O	59 A	60 W	61 C	62 G	63 B	64 E	65 N	■
■	66 A	67 H	68 K	69 X	70 C	71 V	72 L	73 W	74 Q	■	75 H	76 W	77 V	78 X	■	79 T	■	80 B	81 G	82 K	83 O	84 T	85 L	86 E	87 U	■
■	88 F	89 E	90 S	91 R	■	92 V	93 U	■	94 D	95 L	96 O	97 U	98 P	99 E	100 S	101 V	102 A	■	103 C	104 E	105 D	106 S	107 P	108 Q	109 U	■
■	110 C	111 J	112 L	■	113 B	114 H	115 P	116 C	117 S	■	118 E	119 P	120 C	121 X	■	122 A	123 R	124 H	125 O	126 W	127 P	128 K	■	129 E	130 C	■
131 U	■	132 H	133 I	134 W	135 E	136 O	■	137 G	138 I	139 N	140 X	141 C	142 V	143 A	144 F	145 K	■	146 D	147 G	148 J	■	149 D	150 F	151 M	152 Q	■
153 A	154 H	155 O	156 U	157 W	■	158 O	159 K	160 J	161 A	■	162 P	163 B	164 K	165 G	■	166 V	167 M	■	168 A	169 K	170 V	171 B	172 E	173 D	174 O	■
175 N	■	176 T	177 E	178 J	■	179 O	180 N	181 J	182 D	■	183 J	184 N	185 I	186 W	■	187 T	■	188 B	189 F	190 J	191 U	192 C	193 H	194 K	195 O	■
196 U	197 D	198 M	■	199 I	200 K	201 R	202 P	■	203 J	204 P	■	205 C	206 F	207 J	208 P	209 S	210 D	211 I	212 L	213 W	214 E	215 M	216 T	■	217 M	■
218 E	■	219 D	220 G	221 C	■	222 A	223 F	224 W	225 J	226 K	227 N	228 X	■	229 E	230 G	231 O	232 L	233 U	234 N	235 S	■	236 U	237 L	238 W	■	■
239 C	240 G	241 Q	242 J	243 P	244 X	245 I	246 O	247 S	■	248 D	249 F	250 J	251 S	252 U	253 C	254 N	255 R	256 A	257 G	258 K	259 O	■	260 M	261 D	■	■
262 O	263 W	264 U	■	265 E	266 T	267 N	268 A	■	■																	

A Bacteria usually affecting skin or mucous membrane
222 161 153 66 34 102 143 256 44
168 122 12 59 268

B Capital of Soviet Georgian SSR
188 113 163 10 63 80 171

C $\int_0^x \frac{dx}{\sqrt{(1-x^2)(1-k^2x^2)}}$ (2 wds)
221 9 40 141 205 110 239 116 70
130 103 192 61 253 49 120

D Antecedent; provisional
248 149 105 94 146 210 173 219 261
197 182

E German poet and librettist, 1874-1929 (full name)
104 86 229 43 15 177 214 118 218
5 265 129 64 172 99 135 89
39 32

F Coastal province of Portugal
144 47 88 206 189 21 53 20 223
249 150

G A vasoconstrictor hormone
257 62 29 22 137 16 240 57 81
220 230 6 147 165

H Baron and Lord Chancellor of Britain, 1801-1881
2 67 154 75 124 193 114 132 35

I Endeavor
138 211 199 245 133 41 185

J "What error chokes the _______?" Davies, *Nosce Teipsum* (4 wds)
25 203 7 181 250 183 160 207 225
178 111 242 190 23 17 148

K German youth, 1812?-1833. object of mystery cult (full name)
164 258 145 33 226 169 200 194 159
128 82 68

L Not applicable
212 95 85 112 72 30 232 3 237
54

M Written in symbols, as music
167 13 217 215 260 198 151

N Science dealing with phenomena of rotating bodies
65 175 139 180 36 254 8 234 184
227 267

O "Gravity's Rainbow" in Thomas Pynchon's novel, 1973 (2 wds)
179 231 259 246 155 136 195 37 83
24 42 125 158 96 18 262 58
174 11

P Comedy of Moliere, 1666 (2 words)
162 45 107 98 204 115 14 202 56
243 119 208 127

Q 12th century Portuguese crusading order
108 241 152 74

R Purgation; purification
38 201 91 52 28 123 27 255 50

S Chromosome complement of an organism
117 90 106 235 209 55 247 251 100

T Part of Snorri Sturluson's *Prose Edda*, c1223
176 79 84 51 266 4 187 216

U German humanist and reformer, 1482-1531, ally of Zwingli
156 264 97 252 109 31 87 191 236
131 233 196 93

V Group of islands in the Arabian Sea
101 166 142 71 26 170 92 77 19

W American author, 1862-1937. *The Reef*, 1912 (full name)
73 238 134 60 186 48 263 76 224
126 213 157

X "Our _______ songs are those . . ." Shelley, "To A Skylark"
244 1 228 78 140 121 46 69

Solution to January Crostic

There is less work in flying a large machine owing to the wind gusts, which seem large to a small machine, being relatively small in their effect on a large one. A large machine will plow its way through gusts without any control being necessary, whereas a good deal of warping might be necessary on a small one.

F. Handley Page, "(The case for the) Large Aeroplane", in *Textbook of Military Aeronautics* New York, Century, 1918

A Facetiae
B Hubble Constant
C Abu Hassan
D Neoclassicism
E Difference Engine
F Lewisham
G Every which way
H Yttrium iron garnet
I Pelleas
J At two and twenty
K Gay
L Ethereal
M Linlithgow
N Angiogram
O Rasselas
P Glowworm
Q Elf
R Algorithm
S Erechtheus
T Rigel
U Owen Glendower
V Poggio
W Lai
X Almagest
Y Nicholas Slonimsky
Z English Horn

Trend of Affairs

This Month

Space Exploitation

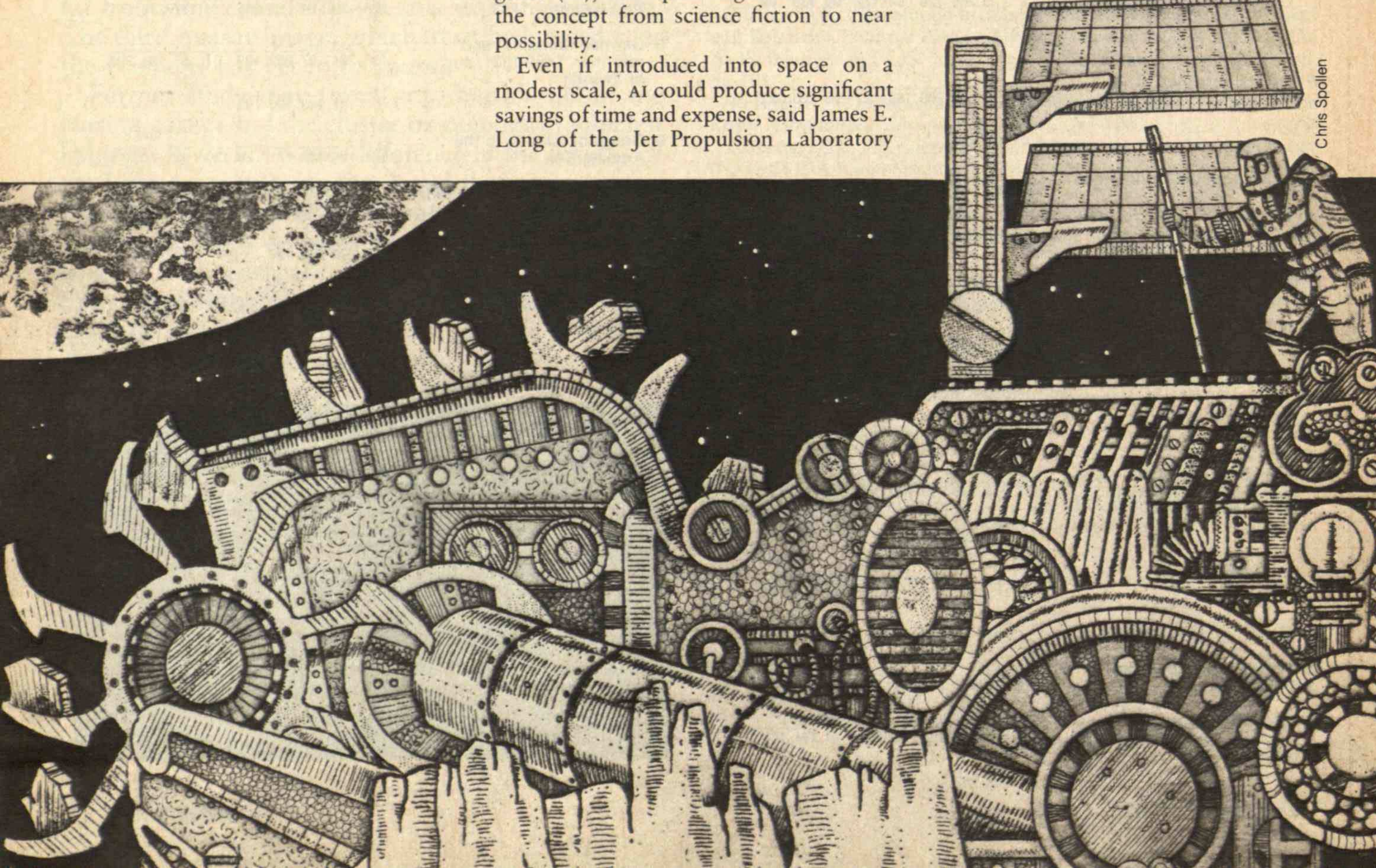
The Seeding of Space

The Lunar Manufacturing Facility ... expands to some predetermined adult size starting from a relatively tiny "seed" initially deposited on the lunar surface. The deployed seed is circular in shape with an assumed mass of 100 tons, and expansion is radially outward at an accelerating rate during the growth phase. Replication and production phases may proceed sequentially or simultaneously with growth activities ... a stepping-stone to replicating manufacturing complexes on the surfaces of other planets ... themselves the offspring of automated self-replicating factories. ...

This vision of extraterrestrial things-to-be comes from the joint conference of the National Aeronautics and Space Administration (NASA) and the American Society for Engineering Education (ASEE) held last summer in Pajare Dunes near Monterey, Calif. The conferees noted that John von Neumann, the Hungarian-American mathematician, devised a similar scenario some 30 years ago; but advances in microcircuitry, artificial intelligence (AI), and space flight have moved the concept from science fiction to near possibility.

Even if introduced into space on a modest scale, AI could produce significant savings of time and expense, said James E. Long of the Jet Propulsion Laboratory (JPL) and Timothy J. Healy of the University of Santa Clara, codirectors of the NASA/ASEE meeting. For example, machines able to cull useful data from the myriad stimuli collected by spacecraft sensors and return to Earth only "desired output" would make analysis much faster. The sheer mass of data typically transmitted from a spacecraft such as *Voyager 1* is presently "more than scientists can easily sift through in ... 10 years," they said. And they were quick to add that on-board machine intelligence would make feasible lengthy and dangerous missions that could not be crewed by humans.

On a larger scale, robot factories that utilize extraterrestrial raw materials could yield virtually limitless fruits for a small initial investment. Artificially intelligent robots could be much more productive and economical in space than human counterparts. The cost of maintaining a human crew in orbit, including launch and recovery, is about $2 million per year per person, according to Ewald Heer of JPL, and astronauts can perform only about two hours of zero-gravity extravehicular activity per day, boosting costs to about $100,000 per hour per person. He estimates that intelligent



Chris Spollen

machines could save NASA from $500 million to $5 billion per year.

Still needed to launch AI into space are talent and funds. A recent NASA report noted that the agency had failed to make "a serious effort to attract bright young scientists," and was "five to fifteen years behind the leading edge in computer science and technology." Members of NASA's New Directions Workshop, held at Woods Hole Oceanographic Institution in the summer of 1979, suggested that the bleak funding picture for space projects had cost exoscientists (specialists in nonterrestrial science) a measure of their "creative vitality and prophetic vision of the future."

Could the stimulus of constructing a self-replicating intelligent factory on the moon fix all that? Discussion of such a project "generated the most excitement" among numerous alternative missions at the NASA/ASEE conference, according to its codirectors, suggesting that such a project might attract the talent sorely needed for its implementation. Intriguing related problems in AI and robotics such as the following are largely unexplored:

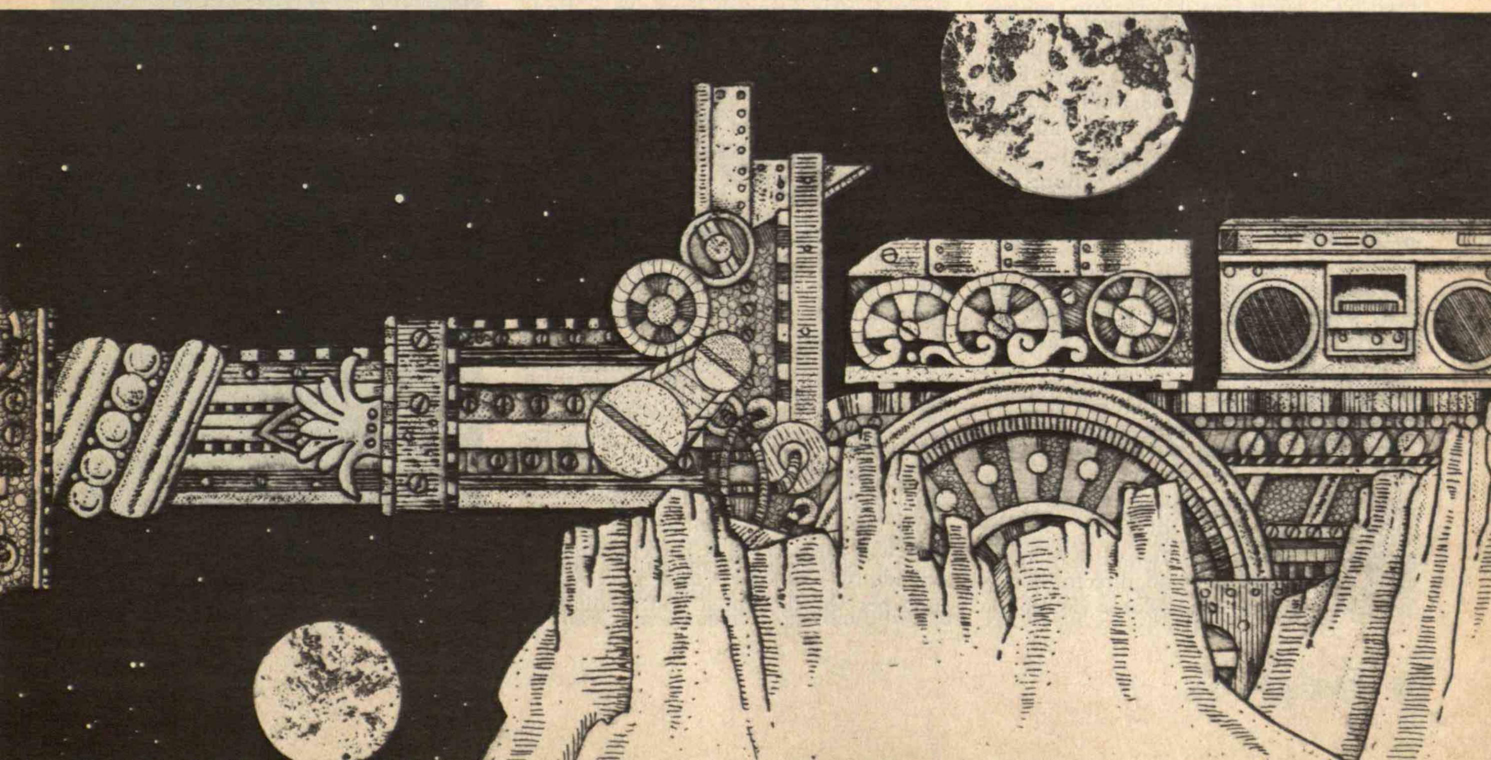
☐ Improving machine vision.
☐ Enabling machines to integrate messages from several kinds of sensors.
☐ Improving robot locomotion.
☐ Developing greater manipulator sophistication.
☐ Enabling machines to make "logical deductions, plausible inferences, planning [decisions], . . . and diagnosis and repair."
☐ Facilitating communication between machines and humans.

Barriers to funding may well be overcome by what appears to be a phenomenal payback potential. For example, a self-replicating lunar factory built from, say, 100 tons of hardware "imported" from Earth would require less than 20 years to manufacture enough solar photovoltaic cells to produce 500 gigawatts of electricity from an orbit around the Earth, according to those at the New Directions Workshop. But a conventional nonreplicating, or "linear," lunar factory — the only type thus far considered (and rejected) for funding proposals — would require about 6,000 years to achieve the same goal. It's hard to imagine anyone turning away a proposal with that much promise. — *L.A.P.* ☐

More Power for Space

The space age is running out of energy technology. A NASA workshop at the University of Maryland has identified nine "unfulfilled technology needs" that now jeopardize the power systems of present and future spacecraft. These include:

☐ Better ways to study power system components. For example, said Luther W. Slifer, Jr., of NASA's Goddard Space Flight Center at the Intersociety Energy-Conversion Engineering Conference in Seattle last summer, no models exist to explain the transient currents known to occur in solar arrays in space. It's assumed that as power demands increase in the future, these transients and their potential for damage will grow.
☐ On-board monitoring and control. Engineers on the ground have too little information — and too much to do — when spacecraft power systems fail to perform correctly. Some of their work should be taken over by automated systems in the spacecraft.
☐ New high-voltage, high-power components. Powerful new scientific instruments and the erection of space platforms will require more power from spacecraft systems, and components to handle the power — and even to measure it — are not available. Already the air force says the failure of high-power amplifiers is "the number-one problem for communication satellites."
☐ New ways of connecting solar cells into arrays. "The failure of solar-cell contacts is a recurring problem," Mr. Slifer said. There are literally millions of such contacts in a large array, and individual inspection is "patently unreasonable." Yet no automated techniques are adequate.
☐ Improved nickel-cadmium batteries. The goal is to have dependable battery performance for ten or more years in orbit, but this goal is not fulfilled often enough.
☐ Better protection against plasmas. As the power and voltage of solar arrays in-



creases, plasma could have "catastrophic effects." New information is needed — almost immediately — to simulate the space plasma environment for testing spacecraft components.

□ Better rotary joints and connectors. Joints and slip rings designed to carry power from spinning to fixed sections of a spacecraft are a constant source of trouble, and as power needs and data-collection rates go up the problems of losses and noise will increase.

□ Better solar array management. Changes in solar arrays to meet a spacecraft's varying needs — more or less power, for example, or to protect elements from overheating — are now assigned to automatic equipment within the spacecraft. But this function should be done within the solar array itself, using devices that don't yet exist such as light-controlled cover slides.

□ New system management. Like the rest of technology, the complexity of spacecraft is outgrowing our capacity for managing it. The solution, said Mr. Slifer, is "a large technology development" — new microprocessors and more information about the functions they are to control. — *J.M.* □

Transportation

Automakers: New Materials for Old

It's all well and good to point out that Newton's first and second laws prove that a lighter-weight car will be more fuel-efficient than a heavier one. But the cost of lightweight materials — aluminum and plastics, for example — is higher than that of steel, and their use often requires extensive design and assembly-line changes. When are they worth the trouble and extra expense?

Parts made of lightweight materials may sometimes simply be substituted for older, heavier parts. For example, aluminum hoods may replace steel ones; molded plastic inner fenders may replace pressed-steel counterparts.

But such "hang-on substitutions" cannot achieve the full savings in efficiency made possible by a "redesign of the entire vehicle to take full advantage" of the weight-reduction potential of new materials, said Julius Harwood, director of material sciences at Ford Motor Co. at the University of Michigan's Management Briefing Seminar at Traverse City late last summer. Obviously, redesign spells added costs. Projected gains in fuel efficiency (and other costs) must keep pace with the costs of changes for overall benefit to the consumer.

One way to figure out the break-even point is to project the energy or dollars saved over the life of the vehicle for each pound of vehicle weight saved because of a materials or design change. If, over the average 100,000-mile life of a car, the cost of saving that pound of weight is compensated by the life-cyle savings in fuel cost, the substitution is worthwhile. For example, one pound of weight saved by simple, "hang-on" substitution is worth about 0.25×10^{-5} gallons per mile. New vehicle designs (for example, that might replace several heavy components with one new lightweight component) can save about 1.0 to 1.5×10^{-5} gallons per mile per pound of weight saved.

Mr. Harwood's calculations indicate that with gasoline priced at $1.20 per gallon, the most cost-effective substitutions involve replacing mild steel components with counterparts of high-strength steel, cast aluminum, molding compound composites, and cast magnesium. Higher gasoline prices could justify the use of wrought aluminum and advanced structural composites.

These and other forecasts in "U.S. Automotive Industry Trends for the 1980s," a Delphi forecast of Arthur Anderson and Co., international financial consultants, indicate that the average car of the next decade will be significantly lighter than today's. This survey of auto manufacturer and supplier senior executives pegs average car weight in the 1985 model year at 2,900 pounds (compared with this year's 3,300 pounds) and at only 2,500 pounds in 1990.

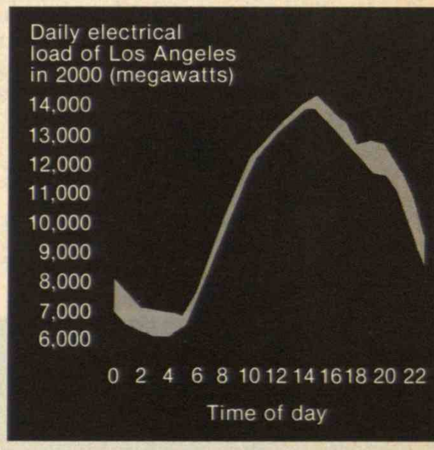
The weight loss will be achieved through continued downsizing and by the use of more high-strength steel, plastic, and aluminum. The proportion of plastics in the average car will grow from this year's 6 percent of average vehicle curb weight to 12 percent in the average 1990 car — about 198 pounds and 300 pounds, respectively — important news for the plastics industry. Aluminum accounts for about 4 percent of the curb weight of today's average car — some 132 pounds; that will increase to 8 percent and 200 pounds by 1990. Less total steel will be used per vehicle, but it will account for roughly the same proportion — 54 to 56 percent — of vehicle curb weight throughout the next decade.

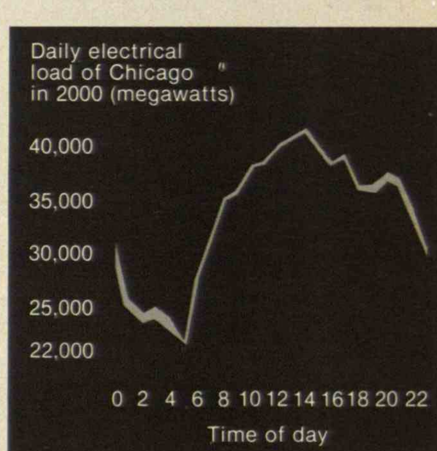
To consumers who for years were taught by Detroit to believe that bigger, longer, and heavier is better, the idea of paying more for less car may be a bitter pill indeed. But it's medicine badly needed if the U.S. auto industry is to regain its robust health.— *L.A.P.* □

Electric Vehicles and the Utilities

What's good for the electric-vehicle (EV) industry promises to be good for electric utilities. Far from being worried about the impact of a growing fleet of EVs, American utilities have "long been fascinated" with them as a means of smoothing load patterns, according to a report from the Electric Power Research Institute (EPRI).

Most EVs are likely to be recharged slowly at night, when significant generat-





ing capacity is idle, EPRI notes. Projections from a sophisticated economic model indicate that over the next 20 years, the lion's share — about 75 percent — of privately owned EVs will be recharged between 9 P.M. and 6 A.M.; 10 percent between 6 A.M. and 9 A.M.; 5 percent between 9 A.M. and 4 P.M. (the peak-load period); 10 percent between 4 P.M. and 9 P.M.

Such a demand pattern would be good news for the utilities — idle equipment cannot bring in revenue — and for EV users as well, because they could pay lower off-peak rates.

But EPRI also says that the net effect of EV recharging on utility loads in the foreseeable future will be "negligible" despite estimates that 12.5 million EVs will be on U.S. roads in the year 2000. EPRI's model indicates that even if optimally placed, EV electrical demand would amount to less than 13,000 megawatts of capacity — about 0.8 percent of the annual national peak, which according to EPRI will be about 1.58 million megawatts. Such a small demand would not go very far toward "leveling" the utilities' daily load curves. (Indeed, even if *all* the estimated 141 million U.S. vehicles in 2000 were powered by batteries recharged with utility electricity, their nighttime peak demand — about 144,000 megawatts — would be less than 10 percent of the national peak.)

But the future of EVs does not necessarily hinge on their load-leveling potential or even on operating expenses. EPRI's economic analysis includes the "somewhat surprising conclusion" that sales will not depend "to any great extent" on the prices of gasoline or electricity, or on performance characteristics such as battery recharging time or vehicle range between charges. Rather, the success of EVs will depend "primarily on the relative initial purchase prices of electric and ICE [internal-combustion-engined] vehicles." Says EPRI, "Even without breakthroughs in battery technology, it is still possible that personal transportation will be largely electrically propelled by early in the twenty-first century." — *L.A.P.* □

Projected daily electrical load in the year 2000 for Chicago and Los Angeles. The upper edge of the shaded area shows the loads expected with a likely electric vehicle (EV) fleet the size of 724,000 in Chicago and just over 1 million in L.A. The lower edge represents electrical loads without EV use. Recharging EVs at night tends to level the daily load curves — but only slightly.

Dreaming of a Chinese Railroad

Santa Claus could hardly have done better than give your favorite railroader a job in the Chinese railway authority. For railroads are center stage in mainland China, the object of careful nurture by a nation committed to their near-monopoly role in industrial transportation.

The land area of China (about 3.7 million square miles) is not so different from that of the United States, including Alaska. In China, this area is served by only about 30,000 miles of railroad track (only 25 percent double-tracked), most of it originally designed by Westerners and positioned for their convenience in bringing Chinese goods and raw materials from the interior to the coast. In comparison, the U.S. has nearly a quarter of a million miles of track.

The backbone of the Chinese rail network's motive power is 7,800 steam locomotives, including some very new ones. It is "the world's greatest collection of steam," says Professor D. Daryl Wyckoff, a Harvard Business School transportation expert who has visited China as a railroad consultant. In addition, there are only 250,000 freight cars and 15,000 passenger coaches in all of China, serving a population nearly five times as large as that of the United States. Management of freight cars is done by dispatchers using telephones, pencils, and pads of paper — scarcely a computer to be found.

What's so great about this undersized, underpowered, undermanaged rail system?

The Chinese assign a high priority to transportation. So when available resources are allocated, the railroads tend to get what they want. And because transportation is in short supply, rail customers come as supplicants, with the railroad ministry empowered to decide who gets what moved where. "A railroader's dream," Professor Wyckoff told a transportation seminar at M.I.T. last fall.

The Chinese reliance on coal-powered steam locomotives is not the result of blind allegiance to an obsolete technology. China has both oil and coal, but its need for foreign exchange dictates that it use coal (for which there is no international market) and export oil. The Chinese are determined to avoid technologies that increase their dependence on oil.

And that telephone-based dispatch system? It works fine: the average Chinese freight car waits only 3.5 days for a new load once it's emptied; the U.S. average is over 20 days. A Chinese freight car spends 34 percent of its time traveling, 39 percent loading and unloading. "You can't see them, they fly by so fast," says Professor Wyckoff. — *J.M.* □

Back to the Iron Horse?

The Chinese decision to run their railroads with coal-fired steam locomotives (*see above*) would be good for the United States, too, says Professor M. Dayne Aldridge, director of the Energy Research Center at West Virginia University.

Total fuel costs for U.S. railroads in 1979, including handling of the 4.3 billion gallons of diesel fuel they consumed, were \$3.66 billion. If the railroads had used coal, the cost would have been only \$2.4 billion (assuming Eastern coal prices), according to Dr. Aldridge's analysis.

The estimate is based on a new locomotive design for heavy-duty freight service utilizing a two-stage coal-fired boiler. The two-stage design reduces peak combustion temperatures so the coal-burner would produce less oxides of nitrogen than a typical diesel; smoke emission would be inherently low, and a cyclone separator in the stack would remove 85 to 90 percent of the particulates.

But the real advantages of a fleet of coal-burning locomotives would be in oil savings and stabilization of U.S. coal demand. Railroads now use just over 6 percent of U.S. diesel fuel; better that fuel be saved for other transport modes that cannot use solids, says Dr. Aldridge. A five-year crash program to reequip the nation's railroads with coal-burning locomotives "would have a significant impact on the importation of oil," an important step toward freeing U.S. industry from dependence on imported fuel. And it would give jobs to 15,000 to 20,000 miners digging the 35 to 50 million tons of coal needed each year. — *J.M.* □

Energy

Imports, Exports, and Energy Risks

The possible health and environmental risks from "unconventional" energy technologies are diverse and difficult to quantify, thus "eluding formal risk-benefit analysis." They are also incommensurable, thereby *resisting* such analysis. "They simply cannot be expressed in the same currency," says Professor John P. Holdren of the Energy and Resources Group at the University of California at Berkeley. Therefore, "risk-benefit analysis must be informal: partly perceptual, personal, and political," he told a symposium at the American Association for the Advancement of Science at its annual meeting last month in Toronto.

No energy source is risk-free, he noted. But "risks exported in space and time — away from users and decision makers — are fundamentally more perverse than those borne by an energy source's beneficiaries." These exported risks elude even informal risk-benefit analysis.

Professor Frank von Hippel (from the Center for Energy and Environment at Princeton University) added an even more somber note to Professor Holdren's themes by observing that "the current level of dependence on oil threatens international economic stability." In fact, said Professor von Hippel, forecast among the energy-derived threats is that of going to war — perhaps nuclear war — over energy supplies. Having built large fractions of their economies on cheap Persian Gulf oil, consuming nations are now "showing signs verging on desperation as they realize how difficult it will be to shift away from it."

A shift to other fossil fuels might avert such confrontation, but it would exacerbate another global problem: the buildup of carbon dioxide in the atmosphere with a consequent raising of atmospheric temperatures.

So what about nuclear power? According to Professor von Hippel: "Despite the protestations of the nuclear industry to the contrary, the spread of nuclear weapons technologies has been closely linked to the spread of civilian nuclear programs [that] provide a convenient 'cover' as well as the training, technology, and material necessary for the construction of nuclear weapons."

"Why do we use so much energy anyway?" Professor von Hippel asked rhetorically. The risks are incurred, he maintained, not from energy need but from energy waste — correctable by better energy efficiency. "Our security would be increased, for example, if we trained our Rapid Deployment Force to reduce residential energy waste and if the funds proposed for the MX were spent to retool our factories to make 60-mile-per-gallon cars." — *S.J.M.* □

Power Without Water?

How shall we turn the energy contained in the vast Western coal fields into the electricity needed 1,500 and more miles away in the populous East?

The answer, for now, is to move the coal by rail to conventional generating stations throughout the East. But there is lively discussion of two proposed alternatives as coal use increases in the future:

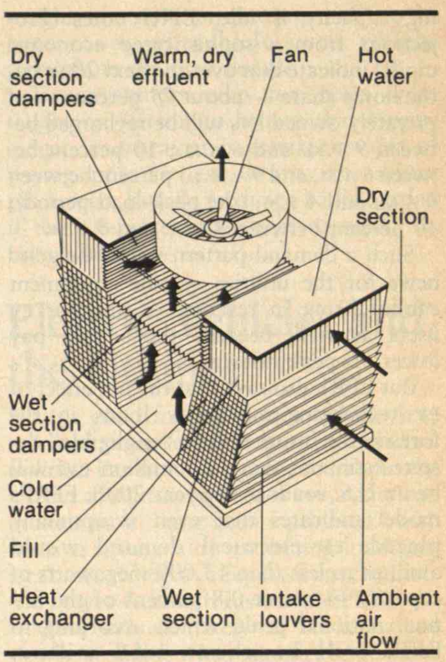
□ Transport the coal through pipelines as a slurry containing 50 percent coal particles and 50 percent water.

□ Convert the coal into synthetic gas and then (by combined cycles) into electricity in mine-mouth conversion plants, and carry the electricity to consumers in ultra-high-voltage lines.

Both these alternatives are flawed, according to E. Stephen S. Miliaras of Energotechnology Corp. and Alexander Kusko of Alexander Kusko, Inc., by their inherent demand for water, which is scarce in the coal fields of the Western plains. The synthetic-gas plan is also flawed by the inefficiency of converting coal to gas.

Now Mr. Miliaras and Dr. Kusko have come forward with a third alternative: burn the coal directly in mine-mouth electric generating plants with a working fluid (water) cooled in "dry" (instead of "wet") cooling towers that depend on air circulation instead of water evaporation as the cooling medium. Then transmit the electric output by direct-current transmission lines to distant customers.

Water is the crucial issue. The gasification-turbine plant would consume between 7 and 10 gallons per minute per megawatt of electricity produced, according to current estimates, and the coal-slurry pipeline would require about 3.5 gallons per minute per megawatt. In contrast, the one air-cooled mine-mouth generating plant in the West — a 330-megawatt station at Wyodak, near Gillette, Wyo. — has been designed to use less than 0.3 gallon per minute per megawatt. Conventional "wet" cooling towers using evaporative cooling of the working fluid seem out of the question, with water demand of 10 to 15 gallons per minute per megawatt. At this rate, a 1,000-megawatt plant would require five times as much water as Cheyenne, the



The dry cooling tower proposed by Alexander Kusko and E. Stephen Miliaras (*left*) is not the only way to reduce the amount of water required to cool the working fluid of mine-mouth electric generating plants in the West's arid coal fields. A "wet-dry" tower manufactured by Ecodyne Corp. (*above*) and tested for the Electric Power Research Institute by D. M. Burkhart and his colleagues of Southern California Edison Co. shows water savings of about 20 percent over a conventional "wet" cooling tower. The "wet-dry" system works this way: A central fan draws air through both "wet" and "dry" sections of the near and far units. Water flows from top to bottom, bypassing the upper "dry" section but cooling the working fluid in the lower "wet" section. The amount of air circulating in the "wet" and "dry" sections can be controlled by dampers, and the tower can be operated in all-wet or all-dry modes or a combination of the two.

largest city in Wyoming.

Can the same abstinence be maintained with improved efficiency in a scaled-up air-cooled plant? Research on that question, and on the emissions control and ground-level electric-field effects under direct-current transmission lines, is next on the Miliaras-Kusko agenda. —*J.M.* □

Sandy Oil at the Margin

When they needed some sticky stuff to patch a leaky canoe on a hot day, the Athabasca Indians used black ooze from a sandy hill near where Beaver Creek entered the Athabasca River, in what is now northeastern Alberta. Perhaps half a century later, the miners of northeastern Oklahoma were finding the same black sticky stuff a frustration: they had to clean the night's accumulation from their pits before they could begin digging for lead and zinc.

In some respects, these early encounters with the bitumen in tar sands were prophetic: the Canadian resource is now used to supplement dwindling supplies of conventional petroleum, while the little-known U.S. tar sands may well have potential more for frustration than utility.

Where erosion has brought conventional petroleum reservoirs to the surface, the viscosity of the oil is increased. By definition, the oil in this tar-sand formation cannot move through the sand toward a well point as in a deep formation. Indeed, the stuff has many of the characteristics of a lean mixture of blacktop.

In comparison with the Canadian resource — which represents a reserve of 900 billion barrels of oil — U.S. tar sands are small indeed. The total oil in the 43 largest occurrences, mostly in Utah, is thought to be somewhere between 25 and 36 billion barrels; the single largest U.S. deposit is in the "tar-sand triangle" in southeastern Utah (12 to 16 billion barrels), and the most concentrated is in Asphalt Ridge (1 to 1.2 billion barrels) in the northeastern corner of the state.

The principal Canadian tar-sand resource can be reached by strip mining, and the technology utilized there is impressive more for its size than its style. Draglines with 60-cubic-foot buckets are used to move the 50 feet of overburden and the 140-foot layer of oil-bearing sand in the Syncrude Canada, Ltd., lease. The extraction process is simple: wash 11,800 tons of sand an hour with caustic hot water to draw out most of the bitumen at the rate of about 130,000 barrels a day. With the bitumen come over 1,100 tons of sulfur. Canadian environmental law permits 140 tons of the sulfur to be discharged daily into the air as sulfur dioxide, and the remaining 1,000 tons becomes a moderately useful by-product.

Before Syncrude Canada lifted the first shovel of sand, the Archeological Survey of Alberta made a detailed review of the prehistoric resources of the 7,000 acres affected by Syncrude's operation: "A society with little or no understanding of its past lacks a full understanding of its identity," explained H.L. Diemer to the American Chemical Society last summer. Some 34 prehistoric sites were identified, producing 11,500 artifacts.

With digging underway, environmental problems continue to command attention. For every unit of oil produced, there are 1.4 units of "tails" — a 185° F mixture of sand, water, and unrecovered bitumen. That represents "a severe water problem, we make no bones about that," D.W. Denney of Syncrude's Research Department told the American Chemical Society. The stuff is now being collected in a pond, the clay and bitumen in the tailings sufficient to seal the pond against seepage. "Mechanical bird deterrents" discourage shore birds from using the pond.

If these difficulties seem a formidable (if ineffective) disincentive for use of the Canadian tar sands, consider the problems for would-be exploiters of U.S. deposits. "Few if any U.S. deposits have overburden-to-deposit ratios as favorable as the Athabasca desposit, and none is believed to have sufficient resources reachable by surface methods to justify the large-scale operations used in Canada," L.C. Marchant of the Department of Energy's Laramie Energy Technology Center told the Intersociety Energy-Conversion Engineering Conference in Seattle last summer. Underground mining to supply a surface extraction plant is too costly given the present price of conventional petroleum. Indeed, only a real technological breakthrough — presumably a way to extract the oil from tar sands without mining them at all — can make the modest U.S. resource useful. Lacking such a system, modern tar-sand advocates are likely to experience the frustration of the Utah lead miners of an earlier era. —*J.M.* □

Living

Does Technology Multiply Errors in the Operating Room?

How much does the design of a medical device contribute to errors in its use?

A team of bioengineers at the Massachusetts General Hospital believes that mishaps can often be attributed to the failure of equipment designers to appreciate fully the role of human factors.

During the past five years, the team, led by Dr. Jeffrey Cooper of the MGH anesthesia department, interviewed more than 100 anesthesiologists and nurse anesthetists to explore 600 errors and equipment failures in the operating room. The interviewees attributed approximately three-fourths of the mishaps to human error and the rest to equipment failure and the premature disconnection of breathing circuits and intravenous apparatus. Although most of the incidents were actually harmless "near misses," the investigators believe the causes of error are the same for more serious mishaps.

The team concluded that their detailed study of incidents heretofore classified as caused by human error yielded insights for the redesign of anesthesia equipment. However, they noted that these insights would not have emerged had anesthesiologists merely been asked directly about their equipment needs. The researchers discovered, for example, that "human errors" involving changes in oxygen flow were more prevalent at one particular hospital than at others. In that facility, anesthesia machines had square knobs for controlling oxygen flow and round ones for nitrous oxide. Although the shapes successfully distinguished the knobs, 8 of 17 "human errors" occurred when an edge of a square knob was accidently struck. Use of less angular controls reduced the frequency of error.

Many of the reported human errors were made by less experienced anesthesiologists working with equipment difficult to assemble and use. For example, a number of errors involved gas-removal systems that could be reversed inadvertently because the exhaust hose could readily be installed backwards. There were not sufficient safeguards to warn users unfamiliar with the equipment.

On the whole, interviewees seemed to

remember human errors much more clearly than difficulties with equipment. They perceived themselves as responsible for errors that could well have been blamed on equipment design — the square oxygen flow knobs, for example.

The MGH bioengineers have applied these insights to the design of a prototype microprocessor-based anesthesia system. The system includes sophisticated monitoring and warning functions that activate alarms, which draw attention to a message board where the difficulties are identified. In other respects, however, the new instrumentation is designed to resemble conventional equipment to avoid confusing anesthesiologists accustomed to older instruments — an important consideration when life hangs in the balance. — *Barbara Goldoftas* □

A Skeptical View of Diet and Cancer

Americans have a healthy appetite for tips on cancer prevention, especially ones involving nutrients, minerals, and vitamins. But the benefits of such dietary supplements are scientifically unproven and probably illusory.

There is insufficient evidence to support the notion that the over- or underconsumption of any single dietary component or food can be directly blamed for the incidence of any form of human cancer, say Professor Vernon Young of the Department of Nutrition and Food Science at M.I.T. and David Richardson of Cadbury-Schweppes, Inc. "Good nutrition for nearly all individuals simply involves eating a variety of foods and adjusting energy intake to expenditure," they say. Furthermore, "there is no scientific reason to exclude any food — such as meat or sugar — or any food component, such as saturated fat, from our diet or to depend upon the use of specific dietary supplements."

Advice on dietary supplements, whether given freely by well-intentioned individuals or sold for gain by charlatans, is based on oversimplified and half-truthful interpretations of research findings, claim Drs. Young and Richardson. Consider these examples:

□ Many consumers are persuaded that increased consumption of vitamins A, C, and E will reduce their cancer risk. Yet studies of the effects of vitamins C and E on carcinogens such as nitrosamines in the intestinal tract have only begun. Drs. Young and Richardson admit that evidence suggests that vitamin A deficiency enhances susceptibility to certain cancers in animals and humans, and that pharmacological doses of vitamin A prevent skin, lung, bladder, and breast cancer in experimental animals. Yet practical uses of these vitamins in the prevention of human cancers is undetermined. Indeed, large doses of such vitamins are wasteful and potentially dangerous. For example, doses of vitamin A far in excess of the federal Recommended Daily Allowance can produce symptoms of poisoning such as blurred vision and bone and liver damage.

□ Selenium and iron are often assumed to inhibit malignancies, while zinc is supposed to encourage them. Recent research shows a positive correlation in some Japanese populations between mortalities from stomach cancer and the zinc content of groundwater and rice. But Drs. Young and Richardson emphasize the many problems involved in relating trace elements to disease, and so far there is little direct evidence to justify changing recommended mineral intake levels.

□ Another popular belief links dietary fiber deficiency with the development of colon cancer. Fiber may suppress colon cancer by diluting potential carcinogens or by reducing exposure to fecal carcinogens by decreasing the transit time of food through the large intestine. Although epidemiological evidence is limited and clinical evidence absent, bran has been found to protect laboratory rats against chemically induced bowel tumors.

Associations between dietary patterns and human cancers have been shown in epidemiological studies and experiments with animals. For example, cancer of the large intestine has been associated with high protein and fat consumption in the United States. But while demonstrating statistically significant associations, epidemiology cannot demonstrate cause and effect, so the derivation of pertinent policy is inherently plagued by uncertainty. And broad extrapolation from animal studies to humans involves fundamental uncertainties.

"It's not a case where two plus two necessarily equals four — that's too quick an answer," say Drs. Young and Richardson. "And if we recommend a diet change, we may end up simply shifting the site of cancer." — *Karen E. Janszen* □

It's Getting Harder to Be Super

Superheroes from throughout the galaxy recently met in Metropolis for the First Joint Conference of Superheroes. This important event was staged in an effort to give new direction to the ailing superhero business: superheroes are falling by the wayside because of advances in technology. Conference chairperson Green Lantern summed up the problem in his opening address: "The fact is," he remarked, "it's getting harder to be a superhero."

Superman gave substance to some of the problems addressed at the conference. "Leaping tall buildings at a single bound is one thing when the building is only 20 stories tall. But modern skyscrapers — some over 100 stories high — are causing me serious concern about future job security. Why, with the speed of some modern elevators, even old Perry White can get to the top of some buildings as fast as I can. Recently, I had to take four bounds to reach the top of the Sears tower in Chicago."

Superman continued, "And as for being faster than a speeding bullet, the new generation of military rifles, including the M-16 and the AK-47, already gives me a close race. I wouldn't be surprised if, in five years, I just won't be able to compete."

The overwhelming concerns of the other superheroes echoed Superman's worries about forthcoming obsolescence. The Flash, for example, proposed that the conferees form a joint committee to look into pension options for superheroes forced out of work. This was adopted by the conference, and the Flash was named as chairsuperhero. Also on the pension committee are Bruce Wayne of the dynamic duo, Batman and Robin. Wayne favors adoption of a plan similar to Social Security in which earnings of all superheroes are taxed to form a general fund.

Aquaman, whose ability to talk to fish is not in technological jeopardy and whose skills are increasingly in demand as offshore drilling, shipping, fishing, and ocean-mining activities increase, had sharp words against such a plan. "If Batman and Robin don't have the skills to remain competitive in the superhero business, they should get out. They can always get work as a comedy act, like Jerry Mahoney and Knucklehead Smith. If the free market doesn't require their services, then they should find another market — not leech an existence from those who have remained competitive in changing times. Why should I subsidize people who offer nothing in return? Sure, Superman, Flash, and some of the others want a free ride. But I have my own row to hoe. Let them take care of themselves."

Scientist Bruce Banner, whose research efforts led to the development of his superstrength alter ego, the Hulk, had a different view. "A pension plan is treating the symptoms and not the causes," he said. "What we need is a concerted research effort to keep up with developing technology. Aquaman feels confident about his future now, but it won't be long before he is in the same boat as the others."

Banner proposed a two-pronged research effort. One branch would look into advanced applications for supertalents already possessed. For instance, Superman could use his x-ray vision to evaluate stresses in bridges, dams, and buildings.

A second and even more important research area is the development of new superpowers. "As my own work has proven," he said, "superpowers can be developed scientifically. We must strive for innovations that will keep us ahead of new developments in crime. For example, with the upsurge in electronic bank robberies, there is a serious need for someone to oversee data-processing operations around the world. 'Chipman' or 'Chipwoman' could monitor electronic pulses in the world's communications networks to lead them to the culprits. And 'Memoryman' or 'Memorywoman' could preclude the consequences of common computer failures that erase memory banks. The ramifications of these data losses are both costly and, when involving defense or crime-fighting files, dangerous."

Banner's comments were met both with interest and skepticism. Remarked fellow scientist Braniac 5, "While the superheroes generally possess above-average intelligence, many are still skeptical of pursuing scientific solutions. They tend to see science as their enemy — the force that is creating their obsolescence. It is therefore hard for them to support research."

But Banner's proposal did garner enough interest that Lantern also created a committee to investigate the feasibility of research-oriented solutions. And although a date has not been finalized, the conferees agreed to meet again this winter in Gotham City to review the reports of the two special committees.

The conference ended on a humerous note with an annoying appearance by the imp from the fifth dimension, Mr. Mxyzptlk. However, John Jones, Martian Man Hunter, was able to induce the imp to say his name backwards, thus sending him back to his own dimension.—*Jeff Stollman* □

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Forum/Continued from page 9

tronaut space program. The successes of the Voyager project have bolstered calls for more instrument probes, but it is unlikely that the frequency of these will increase. Still, one area that could benefit from Reagan's new policies is defense-related space research — his advisors believe that the United States has fallen behind the Soviets in what they consider a battlefield of the future.

So much for our clouded crystal ball. A sensible observer, stepping back from the transition details, can discern an overall pattern in Ronald Reagan's progress. He has moved steadily over the course of the primaries, the campaign, and the transition from minority, right-wing conservative positions toward the moderate policies that have dominated Washington since 1945. The ideas of Milton Friedman may bring down the house at dinners of the American Conservative Union, but Reagan appears now to want to be the "leader of all the people," including scientists and engineers. ☐

We welcome contributions from our readers to Forum and Special Report. Queries should be submitted to the Forum editor, Technology Review, Room 10-140, M.I.T., Cambridge, MA 02139.

Letters/Continued from page 3

The Cruelty of Time

My great teacher and humanist of Cambridge, Norbert Wiener, has suffered an indignity of time in "Computer Control and Human Alienation" (*October, p. 61*). In an otherwise stimulating article, his name is misspelled twice on page 67 and once more in the bibliography. Time can be so cruel to the greatest of scholars.
Albert A. Mullin
Huntsville, Ala.

Correction

In "Microwaves: How Good and How Bad? (Trend of Affairs, May, p. 84), the Soviet standard unit for exposure to broadcast-frequency electric waves is microwatts per square centimeter, not cubic centimeter. — Ed.

Readers should address all letters to Letters Editor, M.I.T., Room 10-140, Cambridge, Mass. 02139.

1980 DASHER DIESEL. THE BEST MILEAGE WAGON IN AMERICA.

The VW Dasher Diesel not only gets better mileage than any other wagon in America, it gets better mileage than most other cars in America. (EPA est. $\boxed{36}$ mpg, 49 mpg highway estimate. Use est. mpg for comparisons. Mpg varies with speed, trip length, weather.

(Actual highway mileage will probably be less.)

The Dasher Diesel wagon is big enough to hold a fair-sized calf. But the inside is so handsome, you'll want to keep the livestock elsewhere.

"Quality pervades wherever one looks, and it's pleasing to the eye as well as to the touch," says Motor Trend. "It's so nice that you'll feel as if you're driving a much more expensive car."

Breezin' by all them gas stations, you'll recollect what Car and Driver said: "It has a way of going much like that of a fine horse, precise and proud."

So, pardner, if someone tells you there ain't no way to put downright luxury together with downright economy, you can give 'em a quote from us:

"Bull."

VOLKSWAGEN DOES IT AGAIN

That's a lot of miles for a young woman. But Debbie has an advantage. The cars she drives are on the programmed road simulator at the Gulf research facility at Harmarville, Penn.

"By giving Gulf products a hard time on the road simulator, we know they'll give your car reliable protection on the road."

They're all standard cars with their driving wheels resting on aluminum rollers. By programming the rollers, Debbie can take a pair of cars on a simulated trip across the Rockies, and keep two others perpetually shuttling through rush-hour traffic.

In her control room, Debbie keeps track of road speed, oil and water temperature, engine vacuum, and other vital functions.

At the end of 50,000 miles, the cars are removed to a laboratory, where engine parts are measured for wear, and the crankcase lubricant is analyzed to find out, for instance, if a new lube oil additive is performing up to Gulf standards.

To do her job right, Debbie has had to learn to work with complex recording instruments, interpreting oscilloscope traces to make sure that the instruments are hooked up right and the test is running according to plan.

Debbie loves cars, loves her work —and the information she gathers from her 300,000 miles a year is helping keep a lot of Gulf customers' cars running economically.

Debbie Treshok. One of 57,000 Gulf people, helping supply energy for tomorrow.

Gulf people:
energy for tomorrow.

Gulf Oil Corporation